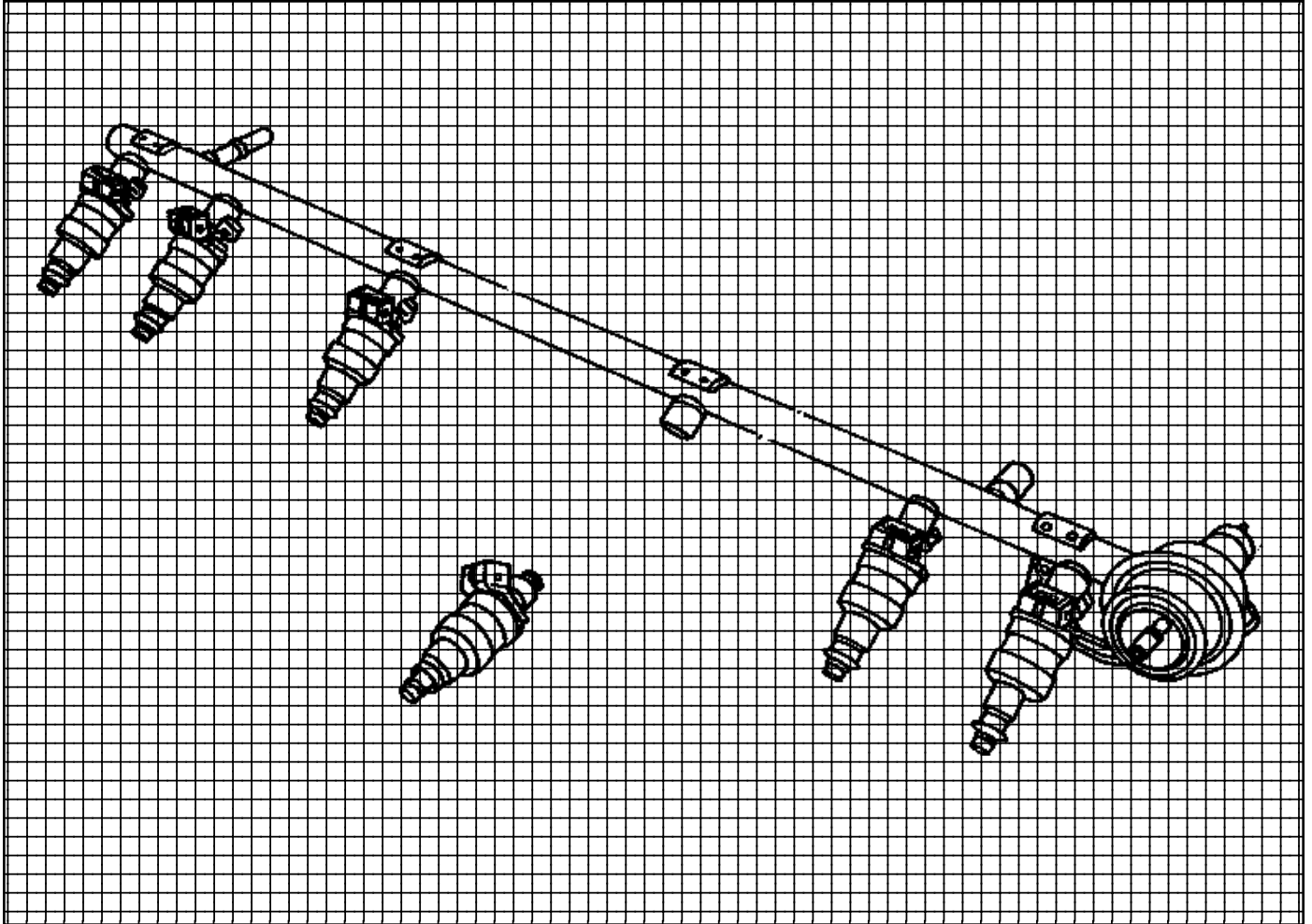


# Jeep®



## **4.0 LITER MULTI-POINT FUEL INJECTION (1987-1990 REXIX System)**

# SAFETY NOTICE

## CAUTION

**ALL SERVICE AND REBUILDING INSTRUCTIONS CONTAINED HEREIN ARE APPLICABLE TO, AND FOR THE CONVENIENCE OF, THE AUTOMOTIVE TRADE ONLY. All test and repair procedures on components or assemblies in non-automotive applications should be repaired in accordance with instructions supplied by the manufacturer of the total product.**

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Proper service and repair is important to the safe, reliable, operation of all motor vehicles. The service procedures recommended and described in this publication were developed for the professional service personnel and are effective methods for performing vehicle repair. Following these procedures will help assure efficient economical vehicle performance and service reliability. Some of these service procedures require the use of special tools designed for specific procedures. These special tools should be used when recommended throughout this publication.

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**Special attention should be exercised when working with spring or tension loaded fasteners and devices such as E-Clips, Circlips, Snap rings, etc., as careless removal may cause personal injury. Always wear safety goggles whenever working on vehicles or vehicle components.**

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It is important to note that this publication contains various **Cautions** and **Warnings**. These should be carefully read in order to minimize risk of personal injury, or the possibility that improper service methods may damage the vehicle or render it unsafe. It is important to note that these **Cautions** and **Warnings** cover only the situations and procedures Chrysler Motors has encountered and recommended. Chrysler Motors could not possibly know, evaluate, and advise the service trade of all conceivable ways that service may be performed, or of the possible hazards of each. Consequently, Chrysler Motors has not undertaken any such broad service review. Accordingly, anyone who uses a service procedure, or tool, that is not recommended in this publication, must assure oneself thoroughly that neither personal safety, nor vehicle safety, be jeopardized by the service methods they select.

**WE SUPPORT  
VOLUNTARY TECHNICIAN  
CERTIFICATION  
THROUGH**



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

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## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### COMPONENT LOCATION CHART

COMPONENT	LOCATION
A/C Thermostat	On evaporator housing
A/C Switch	Instrument panel
Coolant Temperature Sensor	Left side of cylinder block just below exhaust manifold
ECU	Under instrument panel above accelerator pedal
EGR Solenoid	Left inner fender panel next to air cleaner
Exhaust Gas Oxygen Sensor	Exhaust manifold just above exhaust pipe
Exhaust Gas Oxygen Sensor Relay	Right inner fender panel
Fuel Injectors	Between fuel rail and intake manifold
Fuel Pump	In fuel tank
Fuel Pump Relay	Right inner fender panel
Fuel Rail	On intake manifold
Gear Shift Indicator Light	Left side of instrument panel
Idle Speed Stepper Motor	Front of throttle body
Ignition Power Module	Right inner fender panel Behind battery
In-line Fuel Filter	Left frame rail ahead of fuel tank
Knock Sensor	Left side of cylinder block just above the oil pan
Manifold Air Temperature Sensor	Intake manifold behind body
MAP Sensor	Dash Panel above engine valve cover
Pressure Regulator	Front end of fuel rail
Power Latch Relay	Right inner fender panel
Speed Sensor	Left side of transmission bell housing near top
Sync Signal Generator	In distributor
Throttle Body	Top of Intake manifold
Throttle Position Sensor	Front of throttle Body

# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## INTRODUCTION

The 4.0 liter engine used in Jeep Cherokee, Wagoneer, and Comanche models is equipped with sequential multi-point fuel injection. The sequential multi-point fuel injection system has as many fuel injectors as it does cylinders. These injectors are mounted in the intake manifold near the cylinder head. The advantages of multi-point fuel injection are that all of the cylinders receive an equal amount of fuel, and the problem of fuel condensation and puddling is eliminated.

Engine operation is managed by a microprocessor controlled device called the Electronic Control Unit (ECU). The ECU is a microcomputer that receives signals from engine sensors and provides signals to control engine subsystems. As a result of the inputs and the ECU'S operation of actuators, engine performance is controlled by the program residing in the ECU.

The fuel injection system is controlled by the ECU. Based on the information received regarding present engine conditions, the ECU is programmed to provide a precise amount of fuel and the correct ignition timing to meet existing engine speed and load requirements.

The ECU calculates ignition timing and provides a control to the ignition power module. Ignition timing is varied by the ECU as needed to meet present engine operating requirements. Information such as intake manifold vacuum, engine speed, manifold air temperature, and/or the presence of spark knock are used when calculating correct ignition timing.

Because the ECU controls the Engine's operation, it is often diagnosed as the faulty

component during vehicle service, when actually an input sensor or an output actuator is at fault.

### AIR/FUEL MIXTURE

The air/fuel mixture is the ratio of air that is mixed with the fuel before it is burned in the combustion chamber. A proper air/fuel mixture is essential to achieve desired performance, fuel economy, and emissions requirements.

An air/fuel mixture, ideal for controlling engine emissions and performance is 14.7 parts of air to 1 part of fuel (measured by weight).

The proper air/fuel mixture is determined by the ECU which in turn, controls the fuel injectors. The fuel injectors provide pressurized fuel to the intake manifold.

### FEEDBACK

The 14.7 to 1 air/fuel mixture is critical to maintain optimum performance, fuel economy, and emission requirements. To ensure that the proper air/fuel mixture is maintained, the various sensors provide feedback to the ECU for calculation of the fuel injector pulse width. The MAP sensor provides information required for fuel injector pulse width by measuring the pressure (vacuum) in the intake manifold. The Engine Speed Sensor provides the crankshaft position and engine speed information required for fuel injector energization and ignition module timing. The Manifold Air Temperature Sensor and Engine Coolant Temperature Sensors provide the signals required to adjust engine speed and air/fuel mixture for operation throughout various temperature ranges. Based upon the information received from all of these

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### INTRODUCTION

sensors, the ECU is able to calculate a base injector pulse width.

#### OPEN LOOP VS CLOSED LOOP

Air fuel control is achieved by two operational strategies: OPEN LOOP and CLOSED LOOP control. In OPEN LOOP operation, the air/fuel mixture is determined primarily by the MAP, engine speed, and engine coolant temperature sensors.

In CLOSED LOOP operation, the above sensors provide information for the ECU to establish a base injector pulse width, but the Exhaust Oxygen Sensor signal is used to indicate whether or not the calculated injector pulse results in the proper air/fuel ratio of 14.7 part air to 1 part fuel. By monitoring the exhaust oxygen content with the Exhaust Oxygen Sensor, the base injector pulse width can be modified to achieve the optimum air/fuel ratio. An example of CLOSED LOOP operation is a thermostatically controlled household heating system. As the temperature in the house falls below the setting of the thermostat, a signal is sent to the furnace. The furnace is turned ON, and heat is provided. As the temperature of the house rises past the thermostat setting, the signal is interrupted and the furnace shuts off.

#### OPEN LOOP OR CLOSED LOOP DETERMINATION

Operating temperature is determined by the ECU as a result of Engine Coolant and Manifold Air Temperature Sensor signals. The engine is in CLOSED LOOP operation if it is at sufficient operating temperature and either in an idle or cruise condition. At these conditions, the Exhaust Oxygen Sensor is a factor in determining the proper air/fuel mixture.

When the engine is not at a calibrated operating temperature, fuel calculations are based on an OPEN LOOP strategy.

#### WIDE OPEN THROTTLE

The ECU determines a wide open throttle condition by interpreting signals from the Throttle Position Sensor. At wide open throttle, the engine will operate in OPEN LOOP.

#### DECELERATION

When the ECU senses a closed throttle condition through the Throttle Position Sensor and engine speed over 1200 rpm, the engine is in a deceleration state and fuel injection is shut off. Fuel injection is resumed when engine speed decreases below 1200 rpm or if the accelerator pedal is depressed. The engine operates in OPEN LOOP during deceleration.

#### PULSE WIDTH MODIFICATION (ALFACL)

ALFACL is the correction factor used by the ECU to vary the fuel injector pulse width as a result of the Exhaust Oxygen Sensor input. Exhaust Oxygen Sensor values are used in pulse width calculations only during CLOSED LOOP operation. ALFACL varies from 0 to 255 units and represents the degree of correction to the base pulse width.

If the Exhaust Oxygen Sensor reports a rich air/fuel mixture, the ECU will vary ALFACL to modify the base injector pulse width to decrease the amount of fuel being supplied to the engine. If the Exhaust Oxygen Sensor reports a lean air/fuel mixture, the ECU will vary the ALFACL to increase the amount of fuel being supplied to the engine. Control of the air/fuel mixture is optimum during CLOSED

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### INTRODUCTION

LOOP operation where ALFACL is varying at the vicinity of 128 units (midpoint of the scale). When the system goes into OPEN LOOP operation, the ALFACL will return to 128 units and remain fixed. When ALFACL units are increasing, the air/fuel mixture is being enriched. When the ALFACL units are decreasing, the air/fuel mixture is being leaned out. The ALFACL will seldom decrease to 0 (zero) units or increase to 255 units because the Exhaust Oxygen Sensor will usually react to the change in exhaust gas before this occurs. If the ECU cannot control the air/fuel mixture (due to component malfunction or mechanical faults), ALFACL will gradually ramp to one extreme of the scale (0 if too rich and 255 if too lean). If one of these values is reached, the system will default to OPEN LOOP operation.

If ALFACL continues to operate below 128 units and does not increase, the following

conditions may be suspected:

- Fuel pressure higher than 39 psi, which could be caused by a faulty fuel pressure regulator or fuel pump.
- Dirty air filter
- leaky fuel injectors
- Faulty Exhaust Oxygen Sensor/circuit
- Faulty EGR valve operation/circuit

If ALFACL continues to operate above 128 and does not decrease, the following conditions may be suspected:

- Fuel pressure to the injectors is below specification, which could be caused by faulty fuel pressure regulator or fuel pump.
- Clogged fuel injector(s)
- Faulty Exhaust Oxygen Sensor/circuit

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### FUEL SYSTEM

#### FUEL PUMP (Fig. 1)

The fuel pump/sending unit assembly is installed inside the fuel tank. A large flange opening on top of the fuel tank provides the necessary electrical connections and fuel line connections. When installed, the flange seats against the synthetic rubber seal and is held in position by a lock ring. The fuel pump is an electric rotor-cell type. The series wound permanent magnet motor is connected to battery power through a relay. The pumping element contains five roller chambers that alternately draw fuel from the tank and force

it into the fuel lines. Because it is a positive displacement design, the pump requires a pressure regulation device. A pressure regulator located on the fuel rail maintains the proper fuel pressure at all times. The pump itself contains a pressure relief valve that will bypass fuel if the pressure in the supply line exceeds approximately 90 psi. Fuel drain-back through the pump is prevented by a check valve installed in the fuel outlet. The fuel pump utilizes a ballast resistor to reduce voltage to the fuel pump which reduces fuel pump speed and noise. The ballast resistor is mounted on the left inner fender in front of the EGR solenoid.

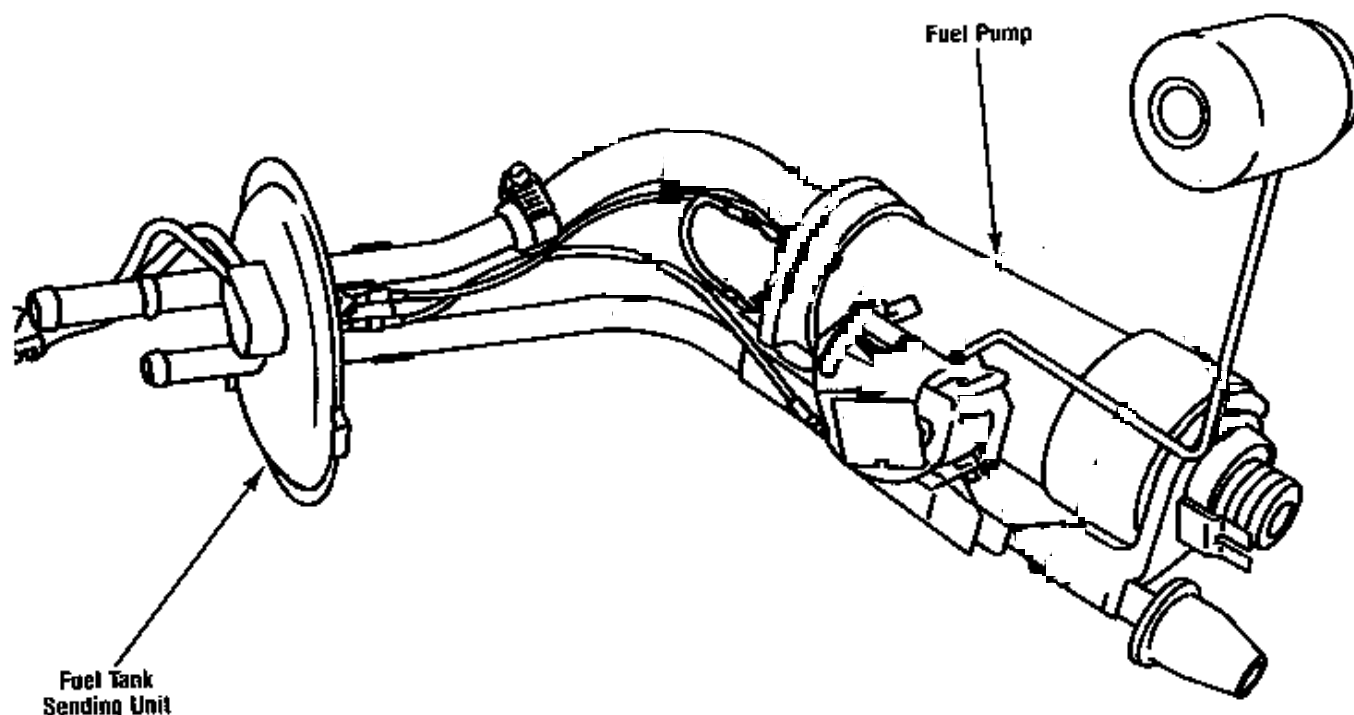


Figure 1 - FUEL PUMP



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### FUEL SYSTEM

#### FUEL PRESSURE REGULATOR (Fig. 2)

System pressure is maintained by the pressure regulator mounted at the forward end of the fuel rail. The Fuel Pressure Regulator contains a diaphragm and a calibrated spring. Fuel pressure operates on one side of the diaphragm while spring pressure and intake manifold vacuum operate on the other side. The spring above the diaphragm is constantly trying to close the outlet to the fuel return line. Fuel acting on the bottom of the diaphragm will open the outlet against the spring pressure. The spring is calibrated to open the fuel outlet when the pressure differential between the injector and the intake manifold reaches approximately 39 psi.

The Fuel Pressure Regulator is also connected to intake manifold vacuum. The connection to intake manifold is necessary to maintain a constant pressure differential between the fuel injector and the intake manifold. The holding pressure of the spring will vary according to the amount of assist it receives from the intake manifold vacuum. With low vacuum, such as full throttle, very little vacuum assist is available and the full force of the spring is exerted to seal the outlet, thus raising positive fuel pressure. With higher vacuum, such as idle, fuel pressure on the bottom of the diaphragm is assisted by intake manifold vacuum, thus reducing positive fuel pressure.

Because a lesser volume of fuel is being used at idle, a greater amount of fuel must be bypassed to the tank to maintain the correct fuel pressure differential. At higher speeds and loads, a greater volume of fuel is being drawn from the fuel rail. Under these conditions, the flow back to the tank must be restricted or a drop in pressure and volume would occur. In short, the pressure regulator maintains a constant pressure differential by controlling the amount of fuel allowed to enter the fuel return line. As intake manifold vacuum changes, the differential pressure between the positive pressure in the fuel rail and the negative pressure (vacuum) in the intake manifold also changes.

#### A Pressure Maintenance Example:

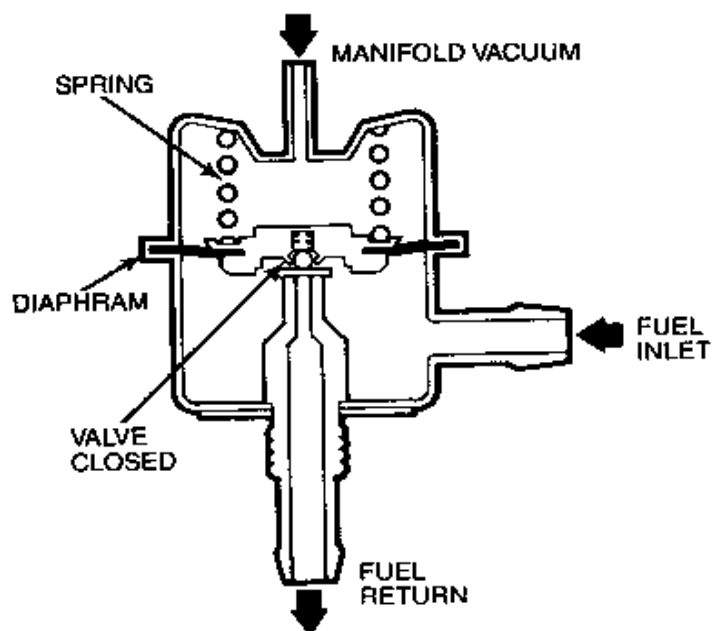
When intake manifold vacuum is a steady 20 inches Hg (-10 psi), the fuel pressure regulator must maintain a positive 29 psi fuel pressure. So under these conditions the fuel system (regulated by the pressure regulator) is pushing fuel through the injector and into the intake manifold at 29 psi.

In addition, 20 inches Hg (-10 psi) of intake manifold vacuum is assisting the fuel supply system by pulling the fuel into the manifold at a negative pressure of -10 psi. Therefore, with the positive fuel pressure pushing at 29 psi and the negative intake manifold pressure (vacuum) pulling at -10 psi, the correct fuel pressure of 39 psi into the intake manifold is established.

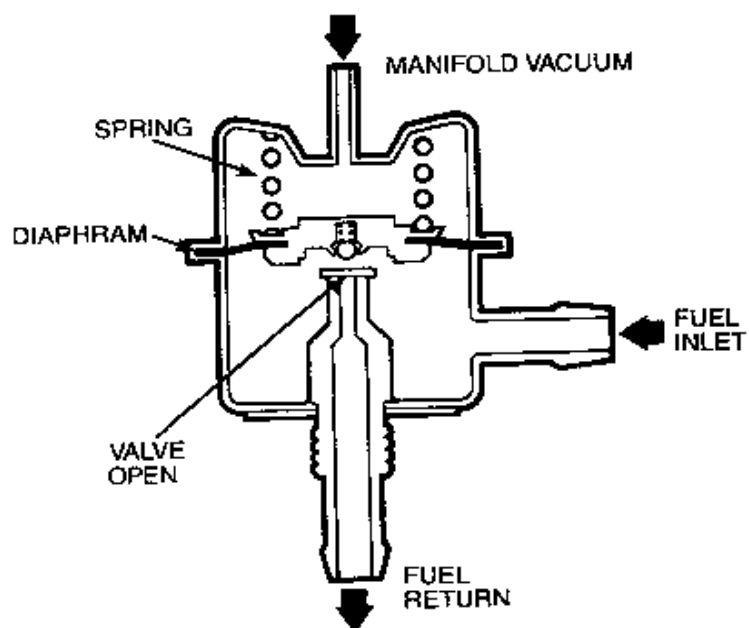
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### FUEL SYSTEM

**REGULATOR VALVE CLOSED**



**REGULATOR VALVE OPEN**



**Figure 2 - Fuel Pressure Regulator**

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### FUEL SYSTEM

#### FUEL RAIL (Fig. 3)

The fuel rail is a manifold with the necessary fittings for connecting fuel lines, injectors, and the pressure regulator. Because it supplies fuel to the injectors, an adequate volume of fuel under a constant pressure differential must be maintained in the fuel rail.

Each injector is installed in a separate fitting extending from the rail and is held in position with a push on spring clip. O-rings are used to prevent fuel leakage between the injector and the intake manifold.

**NOTE:** The injector O-rings are different colors to distinguish their position on the fuel injector. The brown O-ring must be installed on the intake manifold end of the injector. The remaining black O-ring is installed on the fuel rail end of the injector.

A quick connect coupler is used to attach the fuel lines to the fuel rail. There is also a quick connect coupler that connects the return line flexible hose to the metal return line. The quick connect fuel coupler consists of a plastic retainer, two O-rings and a plastic spacer. The retainer engages and locks into position on a raised bead on the fuel line.

Leakage through the connection is prevented by the dual O-ring arrangement and the plastic spacer. To disconnect a fuel line, press in on the ends of the plastic retainer and disconnect the fuel line. Before reconnecting the fuel line, the O-ring seals **MUST** be replaced.

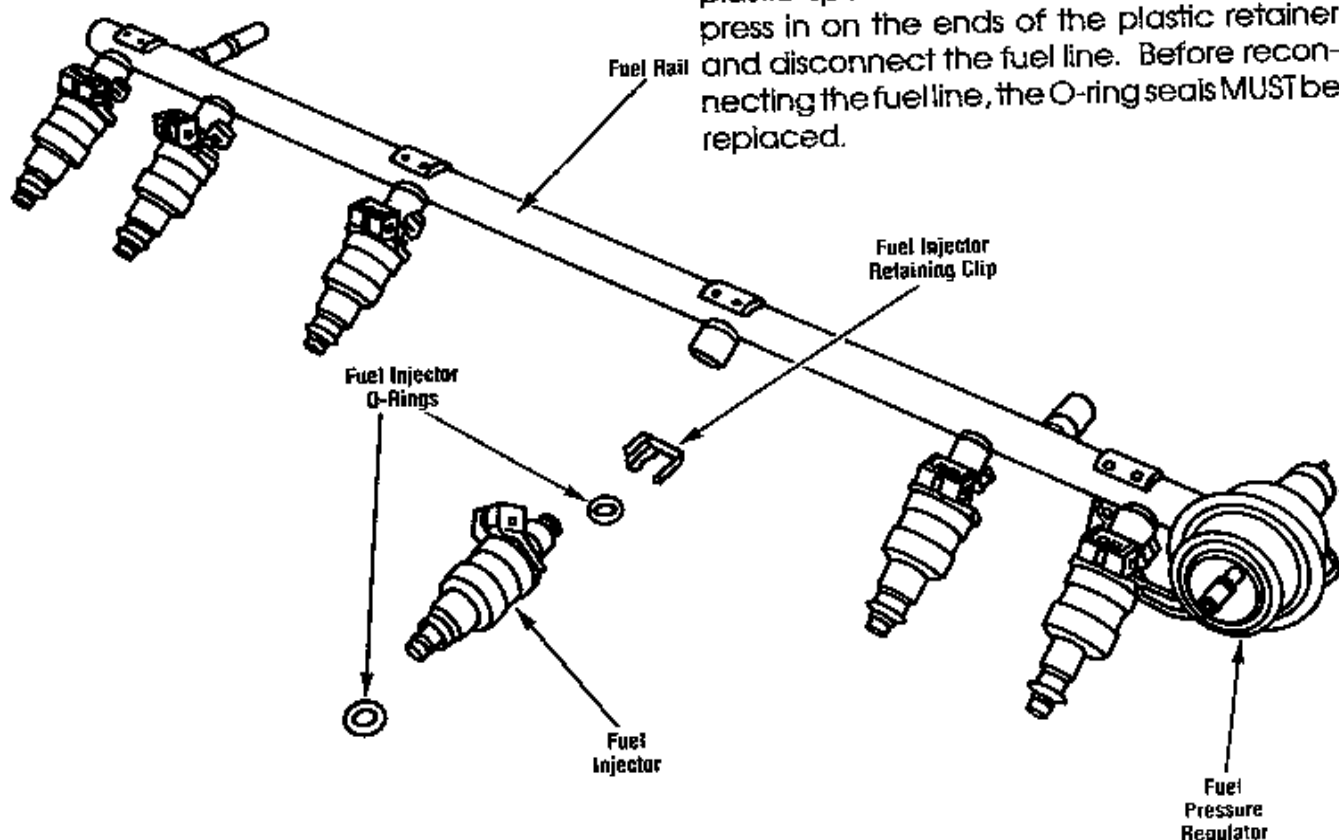


Figure 3 - Fuel Rail

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### FUEL SYSTEM

#### QUICK CONNECT FUEL LINE O-RING REPLACEMENT (Fig.4 & 5)

**Warning:** Fuel system pressure must be released before disconnecting the fuel line couplings. See System Diagnosis section of this book for details.

To disconnect the fittings, the retainer has two tabs that must be squeezed against the fuel tube and then pulled outward to disconnect the fuel tube from the Quick connect coupling. The retainer will stay on the fuel tube when the tube is disconnected. The O-rings and spacer will remain in the connector.

A repair kit consisting of replacement O-rings, spacer, and retainer are available through the parts department. The replacement parts are installed on a disposable

plastic plug.

1. Push kit/disposable plastic plug assembly into quick connect fitting until a "click" sound is heard.
2. Grasp the end of the disposable plug and pull outward to remove it from the fitting.
3. Push the fuel tube into the quick connect fitting until a "click" is heard.
4. Verify that the connection is secure by firmly pulling back on the fuel tube. The tube should be locked in place.

Inspect all hoses/clamp connections for completeness and ensure that no leaks are present.

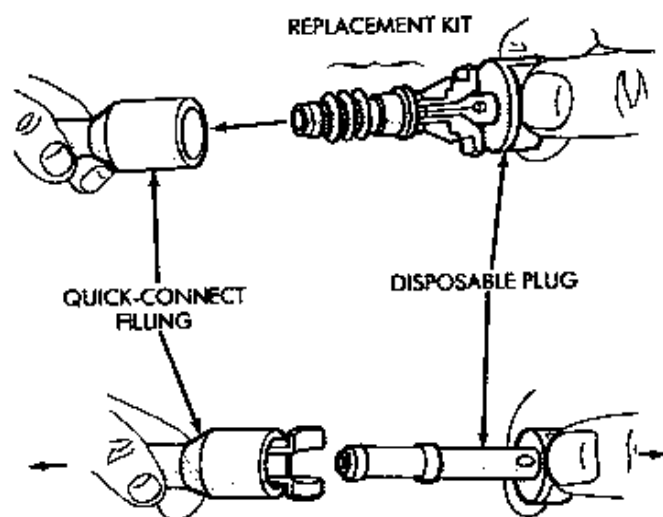


Figure 4 - Replacement Kit Installation

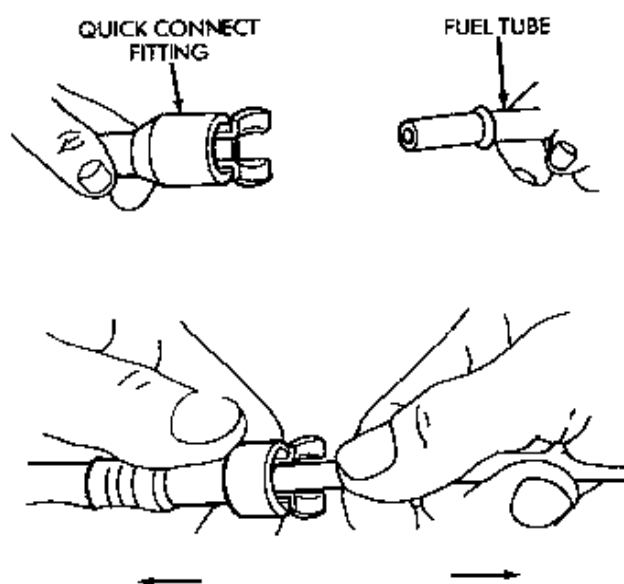


Figure 5 - Installing Fuel Tube

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ELECTRONIC CONTROL UNIT

#### ELECTRONIC CONTROL UNIT (ECU) (Fig. 6 & 7)

The electronic control unit (ECU) manages the operation of the engine control system. It receives information from input sensors that measure engine conditions. After processing this information, the ECU controls a number of outputs which regulate engine performance. The input, processing and output cycle ensures the engine will meet emission, fuel economy and driveability requirements. The ECU is located under the instrument panel just above the accelerator pedal.

The ECU receives information from the following inputs:

- Battery voltage signal
- Manifold absolute pressure (MAP) sensor
- Coolant temperature sensor
- Manifold air temperature sensor
- Exhaust oxygen sensor
- Speed sensor
- Injector sync signal
- Engine crank signal
- Throttle position sensor (TPS)
- Air conditioning select signal
- Air conditioning request signal
- Gear indicator signal
- Knock sensor

The information from these sensors arrives at the ECU in the form of voltage signals. From these signals, the ECU is able to measure engine performance at any given moment and calculate a response.

The ECU contains numerous integrated circuits that include two microprocessors. When the ECU responds, one or more of the following output circuits will be used:

- Fuel injectors
- Fuel pump relay
- Idle speed stepper motor
- Power latch relay
- O<sub>2</sub> heater relay
- EGR solenoid
- Ignition power module
- Shift indicator light
- Air conditioning clutch relay

The ECU can use these outputs to respond either directly or indirectly to engine conditions reported by the sensors. For example, if the oxygen sensor detects a rich air/fuel mixture, the ECU can directly reduce injector pulse width to produce a leaner air/fuel mixture. Indirectly the ECU can control EGR operation by controlling a solenoid that opens and closes a vacuum passage to the EGR valve diaphragm.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ELECTRONIC CONTROL UNIT

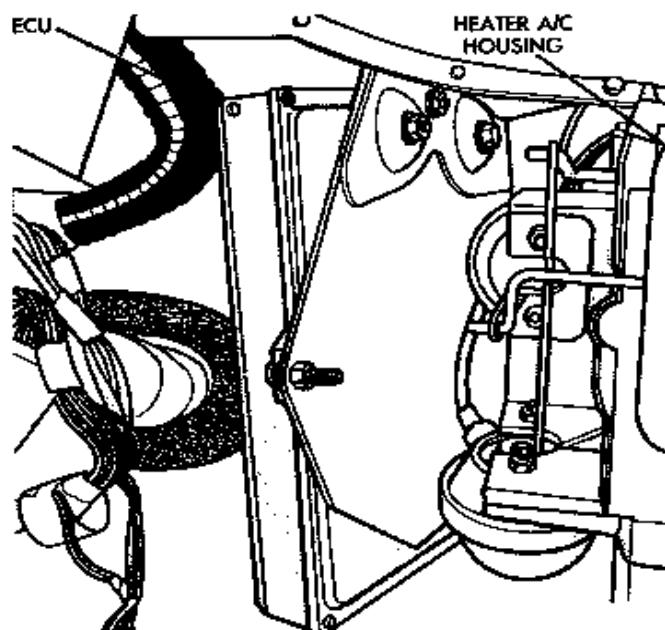


Figure 6 - Electronic Control Unit Location

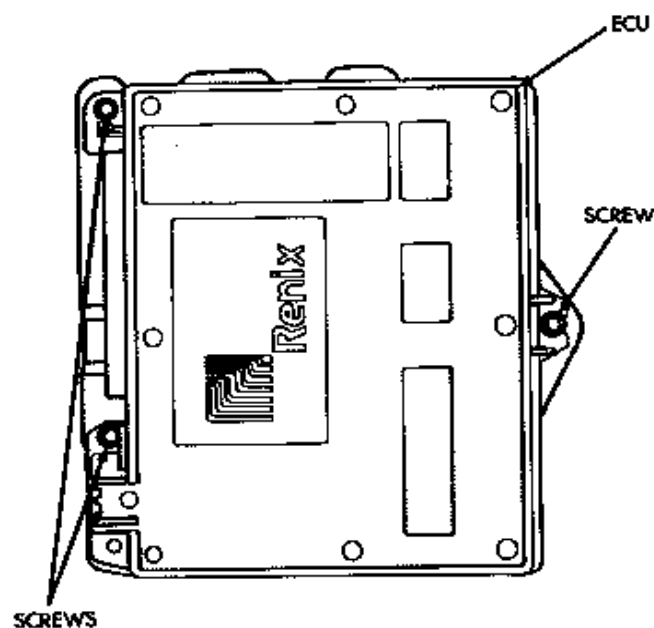


Figure 7 - Electronic Control Unit Mounting Screws

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### MAP (MANIFOLD ABSOLUTE PRESSURE) SENSOR (Fig. 8)

The Manifold Absolute Pressure (MAP) Sensor is mounted on the dash panel above the valve cover. The MAP sensor is the main signal used by the ECU to calibrate the amount of fuel supplied to the engine. This sensor measures manifold absolute pressure and ambient barometric pressure. It provides a 0 to 5 volt signal to the ECU. The MAP sensor receives its input signal from a vacuum hose connected to the throttle body. The MAP sensor puts out a low voltage signal (0.5 to 1.8 volts) at idle when manifold vacuum is high, and a higher voltage signal (3.9 to 4.8 volts) at deep throttle when manifold vacuum is low. Input voltage to the MAP sensor ranges

from 4.8 to 5.1 volts. Adjustments made as a result of this input will usually affect outputs related to:

- injector pulse width
- spark timing
- idle speed
- EGR flow
- shift light
- O2 heater relay

**Barometric Pressure Reading** - The barometric Pressure Value can be used to test MAP sensors. A good MAP sensor will read within 0.60 inches (14 millibars) of the current Barometric pressure after it is adjusted to sea level. To adjust to sea level, subtract 0.1 inches for every one hundred feet or (1.1 millibars for every ten meters) above sea level.

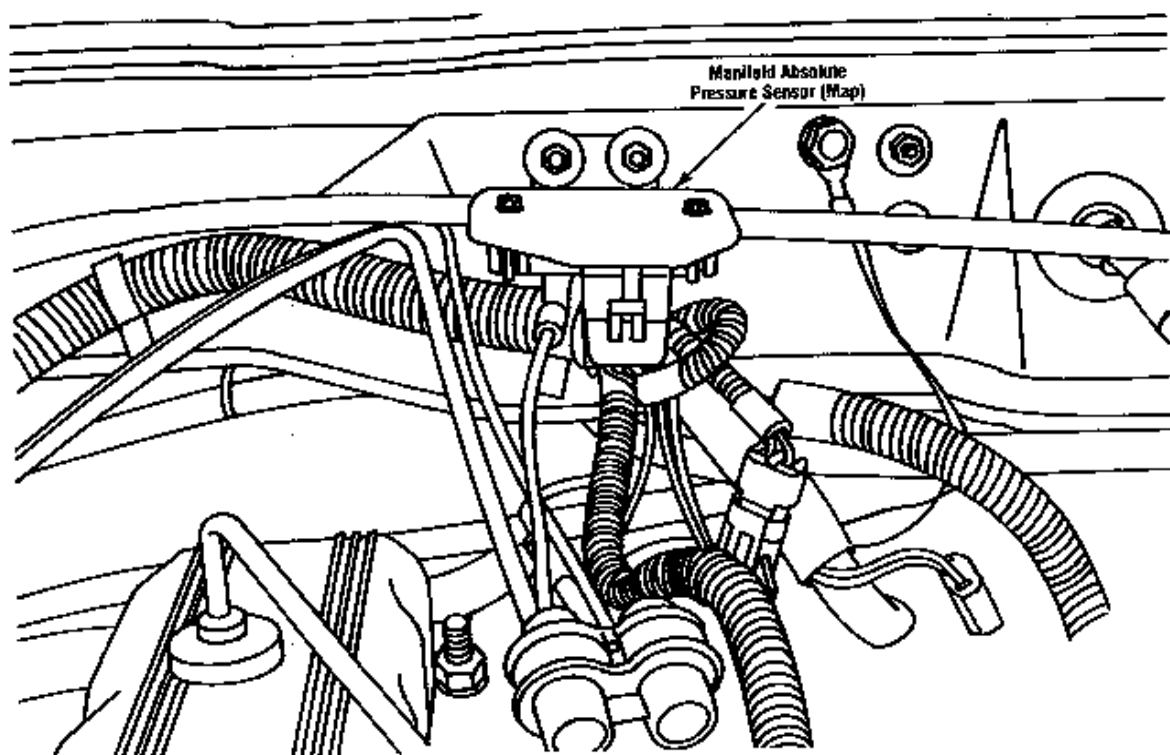


Figure 8 - MAP Sensor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### MAP SENSOR (Fig. 9)

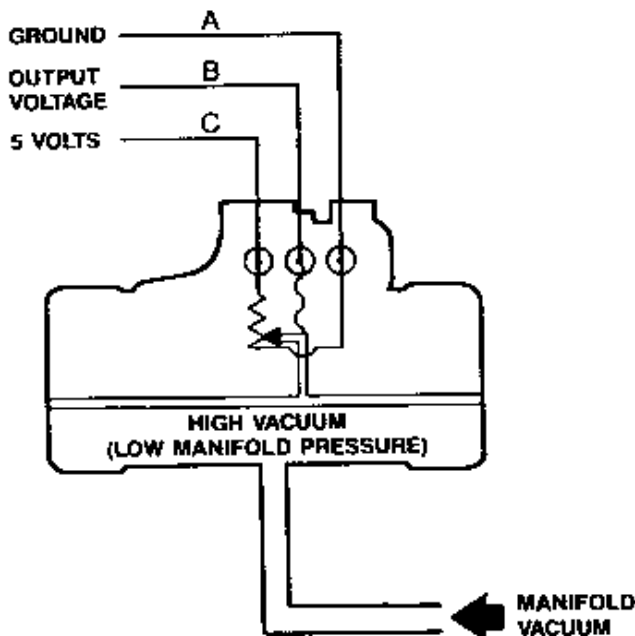
The MAP Sensor is a three-wire pressure sensitive variable resistor. One wire carries an input voltage to the sensor. Another wire provides the sensor with a ground. The last wire carries a return signal from the sensor.

With low intake manifold pressure (high vacuum - usually at idle and cruise conditions), the sensor's resistance is high. With

high intake manifold pressure (low vacuum - usually at wide open throttle or aggressive throttle conditions), the sensor's resistance is low.

Although the input to the MAP Sensor remains constant, changes in air density cause the MAP Sensor's resistance to change. This change in resistance causes a change in the voltage output from the MAP Sensor to the ECU.

- HIGH VACUUM
- HIGH RESISTANCE
- LOW OUTPUT VOLTAGE



- LOW VACUUM
- LOW RESISTANCE
- HIGH OUTPUT VOLTAGE

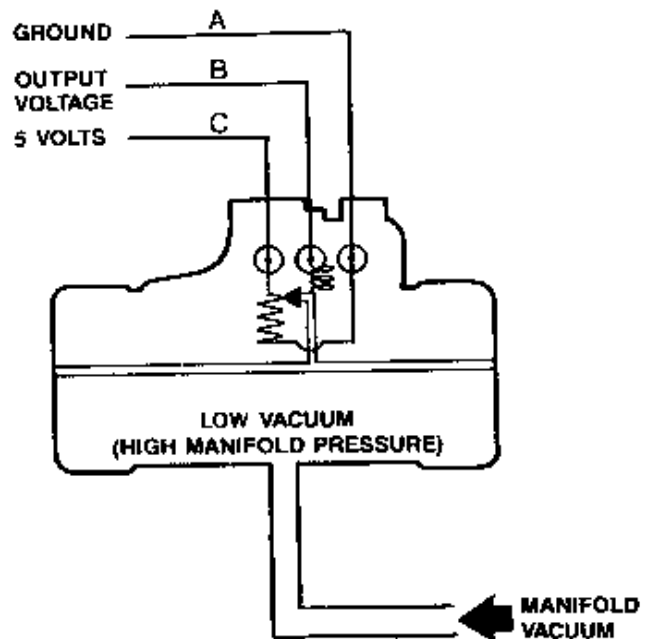


Figure 9 - MAP Sensor Concept Schematic



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU INPUTS

### COMPONENT TESTING

#### MANFOLD ABSOLUTE PRESSURE (MAP) SENSOR

##### Map Sensor Testing

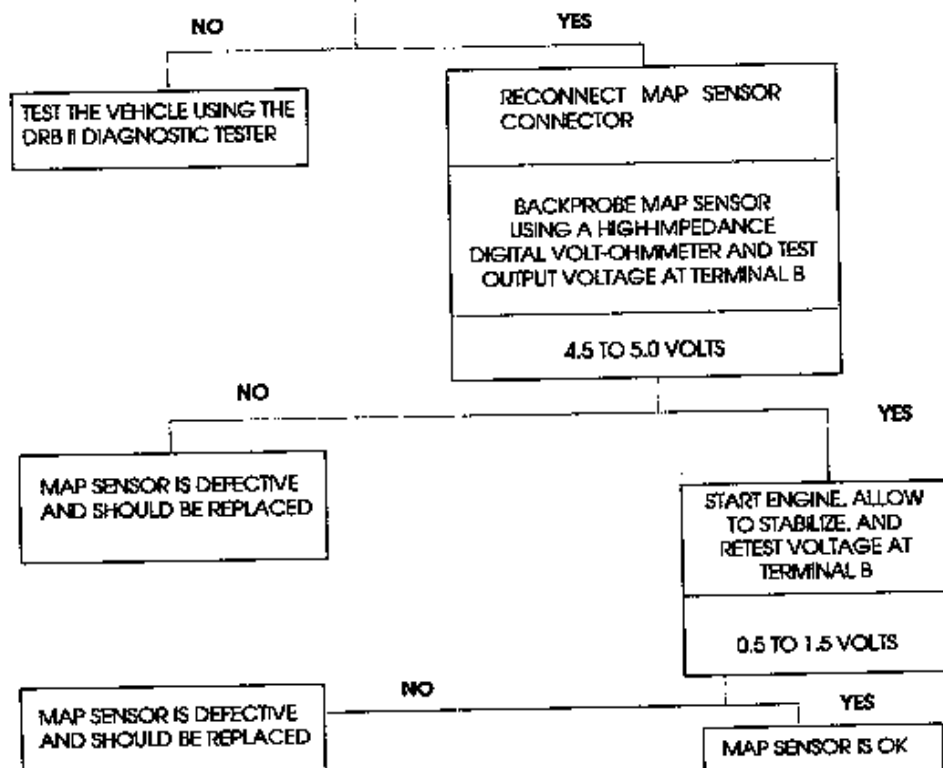
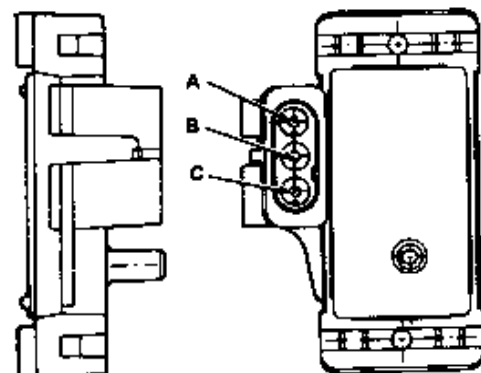
INSPECT FOR COLLAPSED MAP SENSOR VACUUM HOSE. INSPECT HOSE FOR TEARS, HOLES, AND LOW SPOTS. MAP SENSOR HOSE SHOULD BE A STRAIGHT LINE FEED FROM SENSOR TO INTAKE MANIFOLD

REPAIR AS NECESSARY

KEY ON

UNPLUG MAP SENSOR CONNECTOR. TEST VOLTAGE FROM CONNECTOR TERMINAL C TO TERMINAL A (HARNESSE SIDE) WITH A HIGH IMPEDANCE DIGITAL VOLT-OHMETER

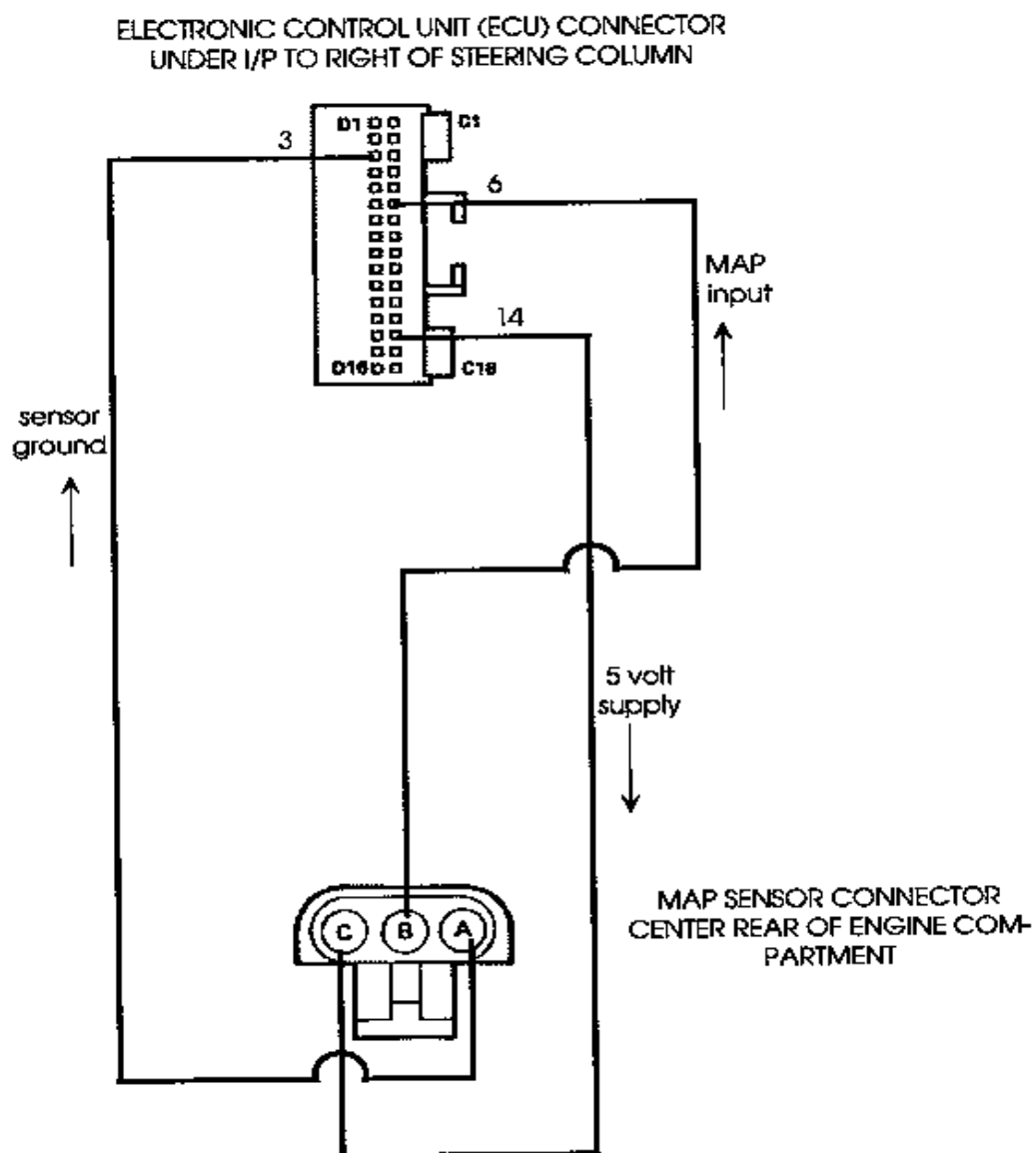
4.5 TO 5.0 VOLTS



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU INPUTS

### MAP SENSOR CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### ENGINE SPEED SENSOR (Fig 10 & 11)

The magnetic speed sensor is mounted on the transmission bell housing where it detects the passing of the toothed flywheel. The signal generated provides engine speed and crankshaft position information to the ECU. The ECU uses this information to determine proper fuel injection and ignition timing.

When a flywheel tooth nears the sensor's magnet, the magnet field begins to shift. The field then snaps back to its original position when the trigger notch is aligned with the sensor, inducing a voltage in the sensor's pickup coil. This voltage is sent to the ECU.

A voltage is generated each time one of the notches passes the sensor. These voltages allow the ECU to actually "count" the passing teeth. Because the ECU knows that top dead center occurs 12 teeth after the trigger notch, it can adjust the ignition timing by counting these teeth. The ECU also uses

information from the speed sensor to determine when to energize the injectors for fuel delivery to the proper cylinders. The toothed flywheel rotating past the speed sensor, contains three notches 120 degrees apart. Each notch is separated by twenty teeth and is used to locate the position of two pistons. Pistons one and six approach TDC at the same time and use the same flywheel notch. Piston two is matched with piston five while piston three is matched with piston four. From the speed sensor, the ECU knows two pistons are approaching TDC. The sync signal generator provides this information.

**NOTE:** The notches are located on the flywheel to relate precise piston position to the ECU. When one of the notches passes the speed sensor, the ECU is informed that the position of a particular set of pistons - such as 1 and 6 - is 60 degrees before TDC. The twelfth tooth after the notch is top dead center.

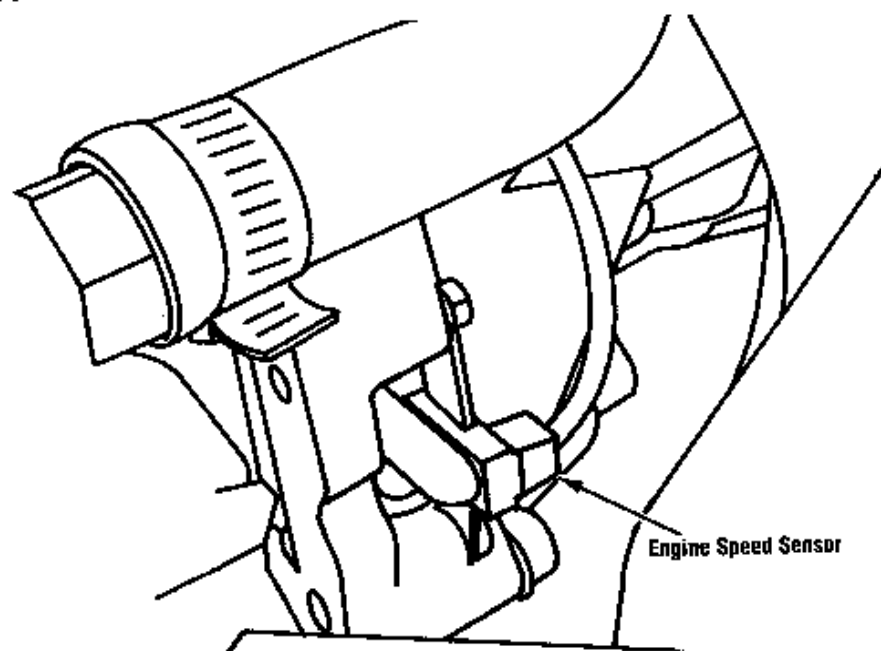
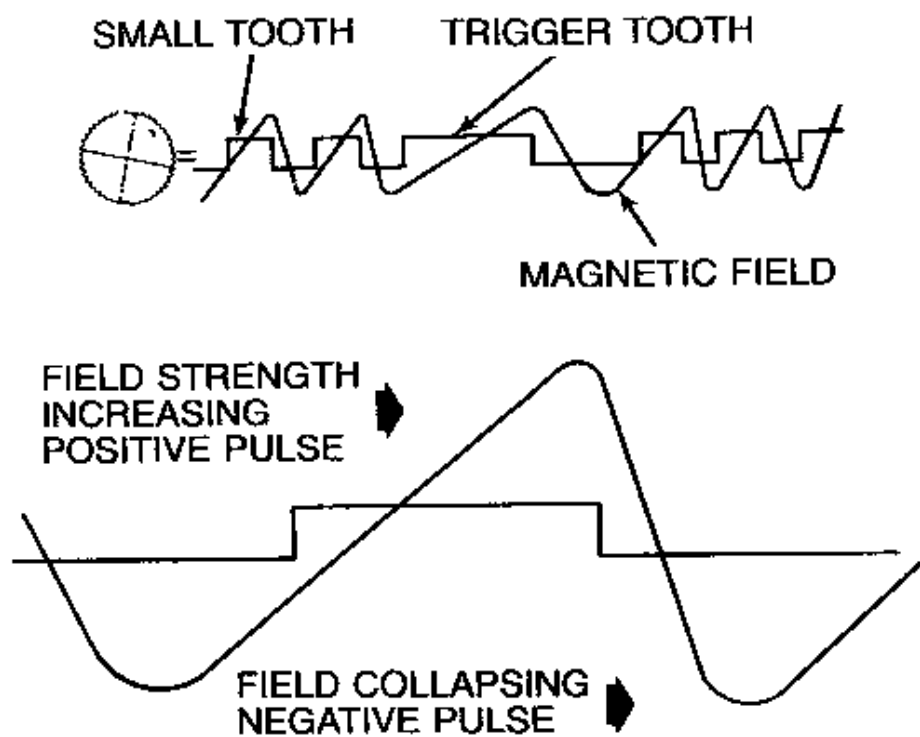


Figure 10 - Engine Speed Sensor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS



**Figure 11 - Engine Speed Sensor Magnetic field Waveform Pattern**

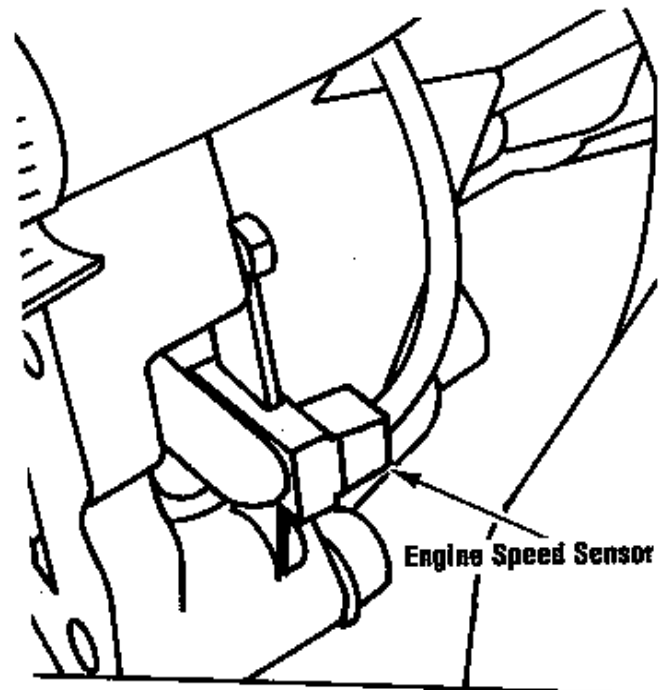
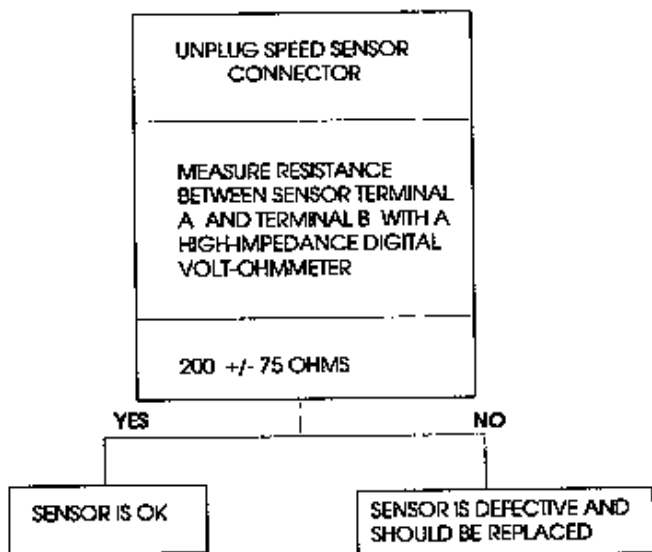
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

##### ENGINE SPEED SENSOR (TDC)

###### SPEED SENSOR TESTING



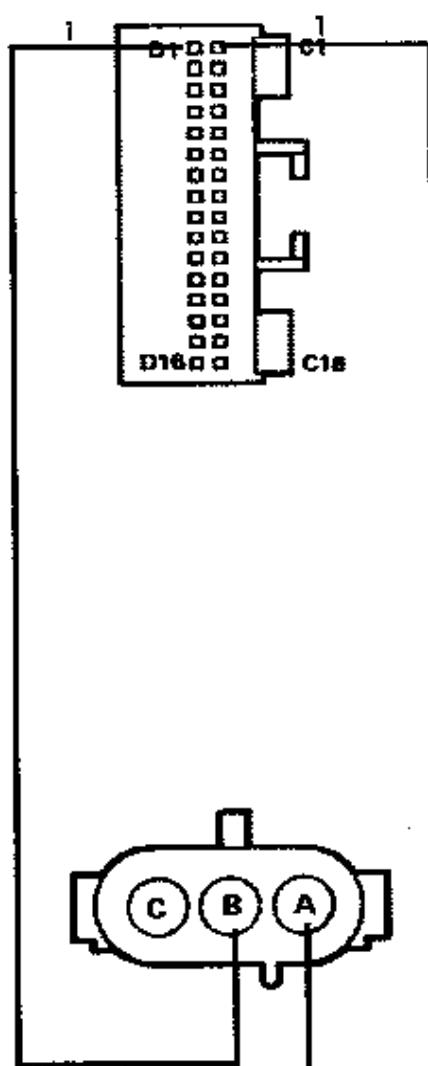
**NOTE: THE SENSOR CAN ALSO BE TESTED USING AN A/C VOLTMETER OR AN OSSILSCOPE WITH THE ENGINE CRANKING.**

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### ENGINE SPEED SENSOR CIRCUIT SCHEMATIC

ELECTRONIC CONTROL UNIT (ECU) CONNECTOR  
UNDER I/P TO RIGHT OF STEERING COLUMN



ENGINE SPEED SENSOR CONNECTOR  
LEFT REAR OF CYLINDER HEAD

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### SYNC SIGNAL GENERATOR (Fig. 12 - 15)

The sync signal generator, located in the distributor works with the speed sensor to provide the inputs the ECU needs to establish and maintain the proper fuel injector firing order. Proper firing order is maintained by locating pistons one and six. As the pulse ring rotates in the distributor it passes through a magnetic field (signal generator). When the pulse ring enters the signal generator, the magnetic field becomes weaker - indicating the position of piston number one. When the ring leaves the signal generator, the magnetic field becomes stronger - indicating the position of piston number six. The ECU receives this information and is able to determine the proper order of injection sequence.

The sync signal generator, is used to locate positions of pistons one and six. The pulse ring rotates through the signal generator for 180 degrees with its leading and trailing edges locating pistons one and six. When the pulse ring enters the generator, the ECU will see the leading edge of the sync pulse telling it that cylinder number one is beginning its exhaust stroke. At approximately 76 degrees before top dead center on its exhaust stroke, fuel is injected into the intake manifold at this cylinder. When the pulse ring leaves the generator, the ECU sees the trailing edge of the sync pulse telling it piston number six is beginning its exhaust stroke. At approximately 76 degrees before top dead center on its exhaust stroke, fuel is injected into the manifold at this cylinder.

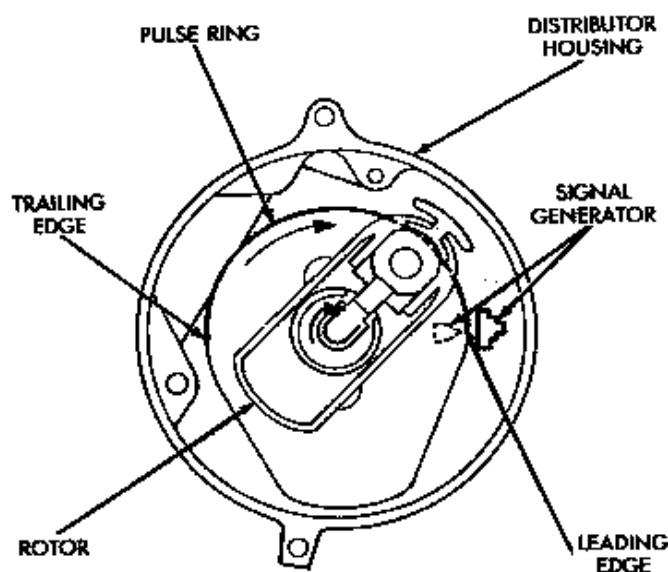


Figure 12 - Sync Signal Generator

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

By looking at both the speed sensor input and the sync signal generator input, the ECU can establish the necessary reference point. When it receives a piston position signal, the ECU then determines the position of the pulse ring. If the pulse ring's leading edge has just passed into the field of the signal generator, the ECU has identified piston number one. If the pulse ring's trailing edge has just left the field of the signal generator, the ECU has identified piston number six. It can now begin firing the injectors in the proper sequence and at the proper time.

The ECU will always open an injector when a piston is on the exhaust stroke. Opening the injector while the piston is still on the exhaust stroke allows time for the fuel to enter the intake manifold and thoroughly mix with the incoming air during the intake stroke.

The sequence of injector timing can be illustrated by following the number one piston through two complete engine revolutions (720°).

#### EXAMPLE:

- The cycle starts with the number one piston at top dead center between its compression and power strokes (0°). At this time, the ECU checks for the possibility of a spark knock. The ECU also checks the sync signal from the distributor and determines that the pulse ring is not passing through the signal generator.

- As the number one piston moves through its power stroke (0° - 180°), the ECU checks the sync signal and determines that the pulse ring is not passing through the signal generator. Near the end of the power stroke, the number one cylinder exhaust valve begins to open.

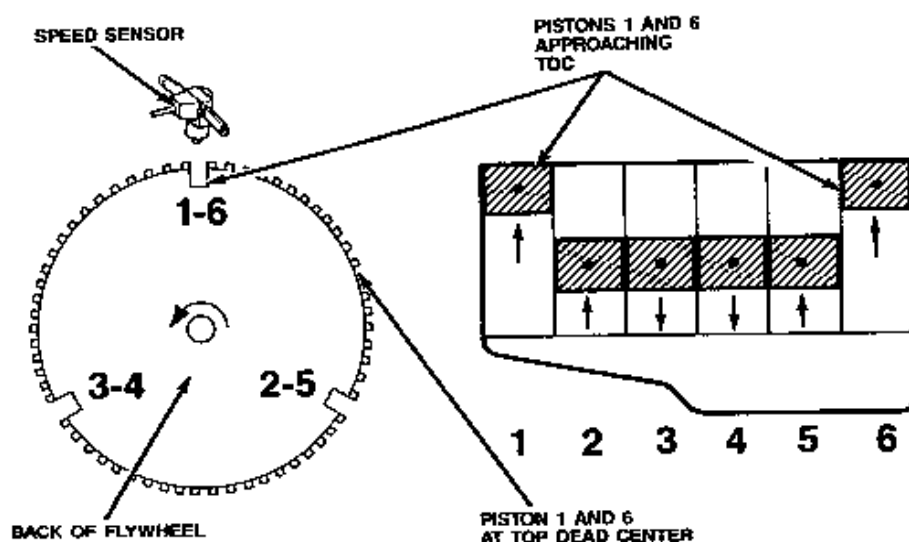


Figure 13



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

- During the exhaust stroke (180° - 360°), the ECU again checks the sync signal. This time, however, the ECU determines that the pulse ring is passing through the signal generator. This informs the ECU that the piston approaching top dead center on its exhaust stroke is the number one piston - not number six piston. (Although both the number one and the number six pistons are approaching top dead center, the ECU has now determined which fuel injector to energize). As the number one piston reaches approximately 76° before top dead center, the ECU energizes the number one fuel injector. Fuel begins to spray into the intake manifold at the number one cylinder intake valve. The duration of the spray (Injection pulse width) varies depending on the input signals received by the ECU.

- As the number one piston reaches top dead center between the exhaust and intake strokes (360°), the exhaust valve starts to close and the intake valve starts to open.

- On its intake stroke (360° - 540°), the number one piston draws a precise air/fuel mixture into its cylinder.

- During the compression stroke (540° - 720°), the number one cylinder intake valve closes and the piston compresses the air/fuel mixture. As the piston approaches top dead center between the compression and power strokes, the ECU signals the ignition power module to fire the number one spark plug. Ignition timing varies depending on input signals received by the ECU.

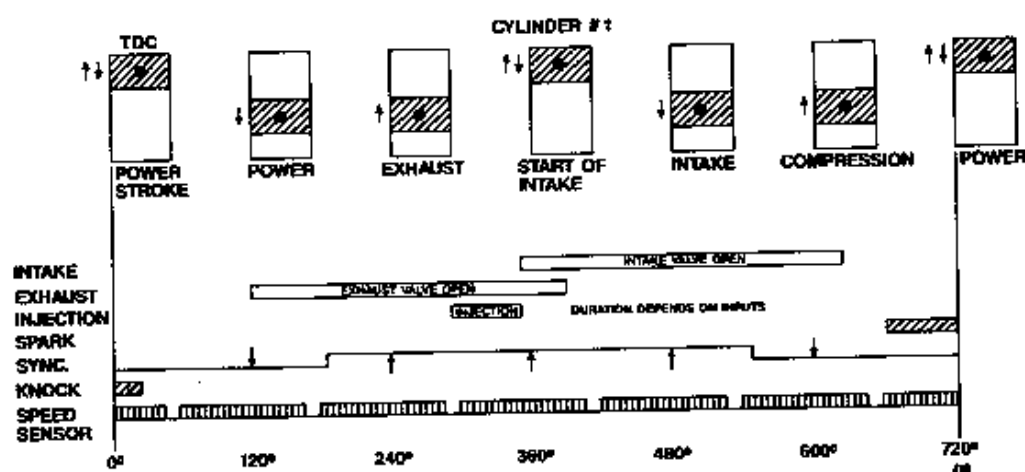


Figure 14

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

- When the number one piston reaches top dead center between the compression and power strokes ( $720^\circ$  or  $0^\circ$ ), a new cycle begins.

**NOTE:** While the sequence of every cycle will remain the same, fuel injection pulse width and injection timing will vary with changing input signals received by the ECU.

Just as the new cycle begins, a snapshot taken of the 4.0L engine cylinders would reveal the following:

- Cylinder number 1 - Piston number one is at top dead center between its compression strokes. The spark plug is firing.
- Cylinder number 2 - Piston number two is 60 degrees ( $120^\circ$  BTDC) into its exhaust stroke.

(Fuel injection will begin as the piston is approximately  $76^\circ$  before top dead center.

- Cylinder number 3 - Piston number three is 120 degrees into its intake stroke drawing the fuel/air mixture into the cylinder.
- Cylinder number 4 - Piston number four is 120 degrees into its power stroke.
- Cylinder number 5 - Piston number five is 60 degrees ( $120^\circ$  BTDC) into its compression stroke.
- Cylinder number 6 - Piston number six is at top dead center between its exhaust and intake strokes. Near the end of the injection pulse width, fuel is still entering the intake manifold at the number six cylinder intake valve.

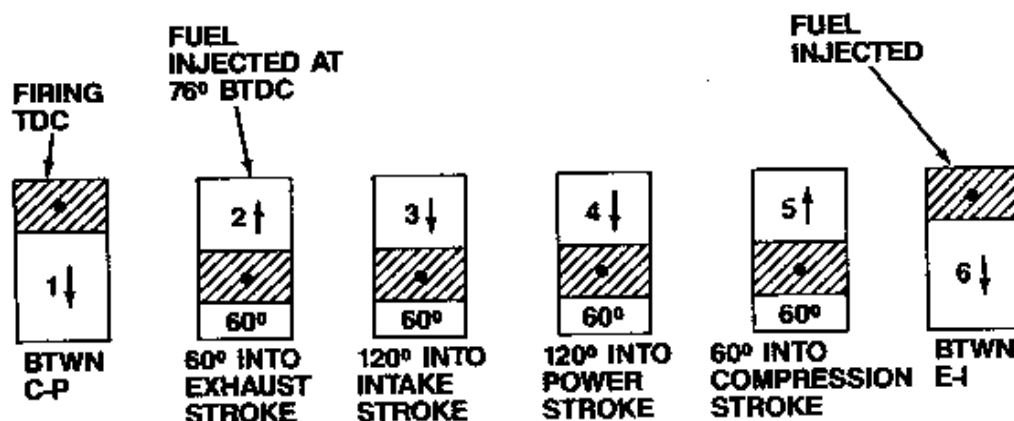


Figure 15

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### COMPONENT TESTING

#### SYNC SIGNAL GENERATOR TEST

The Sync Signal Generator can be tested using an analog voltmeter.

1. Insert the positive (+) voltmeter lead into the Blue wire (terminal B) of the distributor connector.
2. Insert the negative (-) voltmeter lead into the Gray W/tr wire (terminal C) of distributor connector.

**NOTE:** Do not remove the distributor connector from the distributor. Insert the voltmeter leads into the backside of the distributor connector to make contact with the terminals.

3. Set the voltmeter on a 15 volt DC scale. Turn the key to the "ON" position.
4. The voltmeter should show approximately 5.0 volts.

If there is no voltage:

- a. check the voltmeter leads for a good connection. Still no Voltage? Proceed to step b.
- b. Remove ECU and check for voltage at pin C-16 of the ECU connector and ground with the harness connected. Still no Voltage? Proceed to step c.
- c. Perform a diagnostic test using the DRB II and the Jeep/Eagle adaptor.

If voltage is present:

- a. Check continuity between the blue wire (terminal B) at the distributor connector

and terminal C-16 of ECU connector.

If there is no continuity, repair the harness as necessary.

- b. Check for continuity between the Gray W/tr wire (terminal C) at the distributor connector, and terminal C-5 of the ECU connector.

If there is no continuity, repair the harness as necessary.

- c. Check for continuity between the black wire (terminal A) at the distributor connector and ground.

If there is no continuity, repair the harness as necessary.

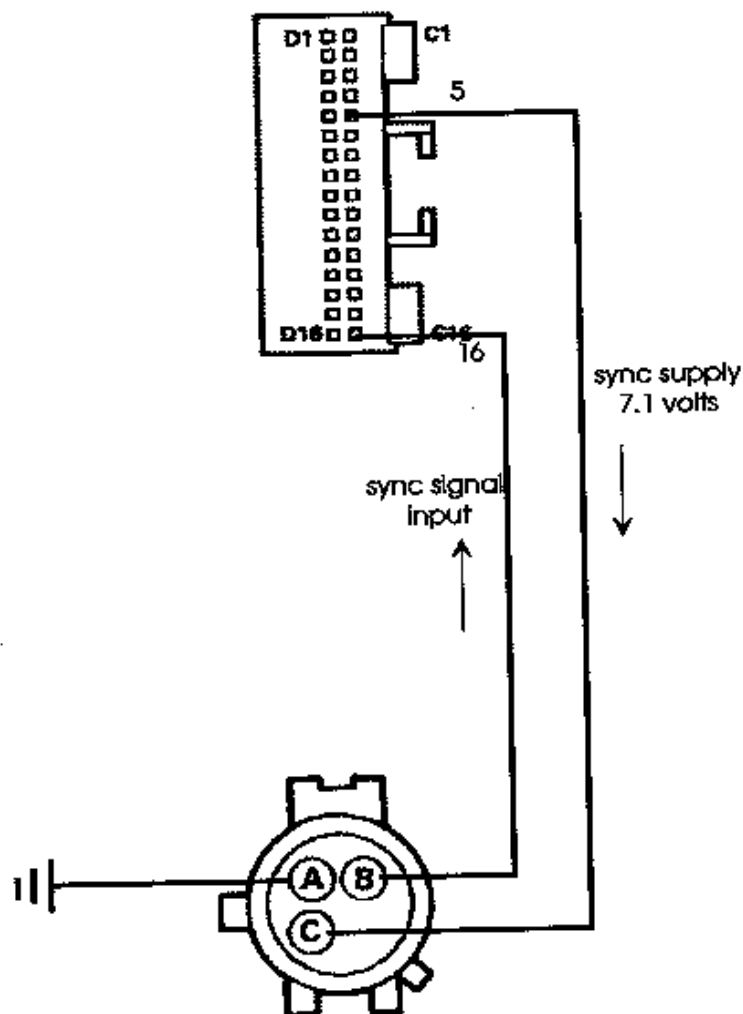
While observing the voltmeter, crank the engine; the voltmeter needle should fluctuate back and forth while the engine is cranking. This verifies that the stator in the distributor is operating properly.

If there is no sync signal generated, replacement of the stator is necessary.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### SYNC PULSE SIGNAL CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### THERMISTORS

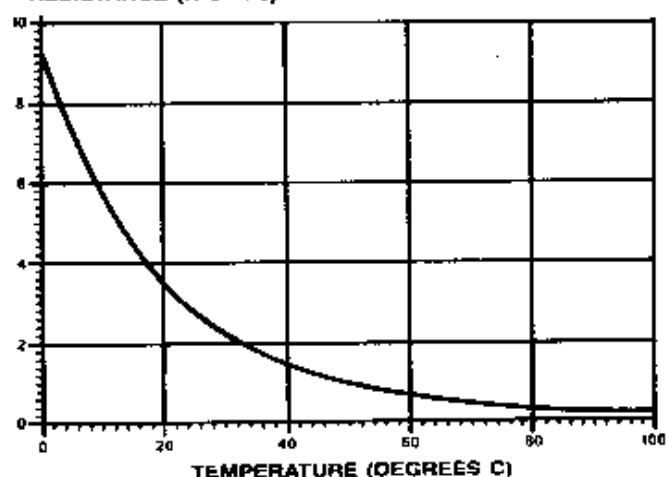
A thermistor is a resistor in which resistance varies sharply and predictably with temperature. The thermistor's resistance decreases as temperature increases, and increases as temperature decreases. The changing resistance affects the voltage drop across the sensor's terminals and provides a signal to the ECU corresponding to temperature.

The change in resistance is not linearly related to the change in temperature. In other words, a change of one degree does not always cause the same change in resistance. There is, however, a definite and predictable relationship between changes in temperature and the sensor's change in resistance. The thermistor Characteristics Curve shows typical thermistor resistance vs. temperature values.

Thermistor sensors must be connected into a voltage divider network. A five-volt reference is first applied to a fixed resistor (located in the ECU) that is wired in series with the thermistor. The ECU then checks the voltage just after or "downstream" of the fixed resistor.

If the thermistor's resistance is high, there is not much of a voltage drop across the fixed resistor in the ECU.

THERMISTOR CHARACTERISTICS CURVE.  
RESISTANCE (K-Ohms)

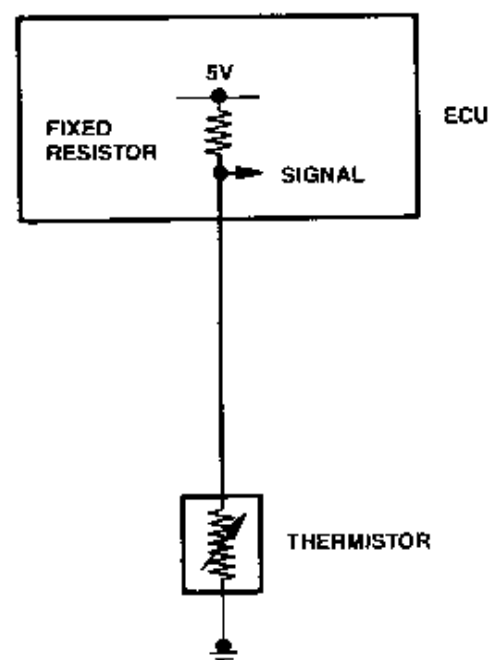


Typical Thermistor Temperature-To-Resistance Curve

With a small voltage drop, the ECU senses something close to reference voltage just after the fixed resistor. In fact, if the thermistor's resistance is infinite (open circuit), the signal voltage will be equal to the reference voltage. (Resistance should never actually reach infinity in a properly working sensor).

If the thermistor's resistance is low, there is a large voltage drop across the fixed resistor in the ECU. With a large voltage drop, the ECU senses a much lower voltage just after the fixed resistor. Should the thermistor's resistance go to zero (short circuit), the signal voltage would be equal to the reference voltage minus the voltage drop across the fixed resistor in the ECU. (Again, resistance should never actually go to zero in a properly working sensor).

TEMPERATURE	↑	↓
THERMISTOR RESISTANCE	↑	↓
FIXED VOLTAGE DROP	↓	↑
SIGNAL VOLTAGE	↑	↓



Thermistor Voltage Network

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### AIR TEMPERATURE SENSOR (Fig. 16)

The Manifold Air Temperature Sensor is located in the intake manifold where it measures the temperature of the air entering the intake manifold. It provides an analog voltage signal to the ECU. The signal is used to compensate for changes in the air density due to temperature.

The air temperature sensor is a NTC thermistor-type sensor, (internal resistance varies opposite with temperature). At cold temperatures, the resistance is high. As the temperature of the air increases, the resistance decreases.

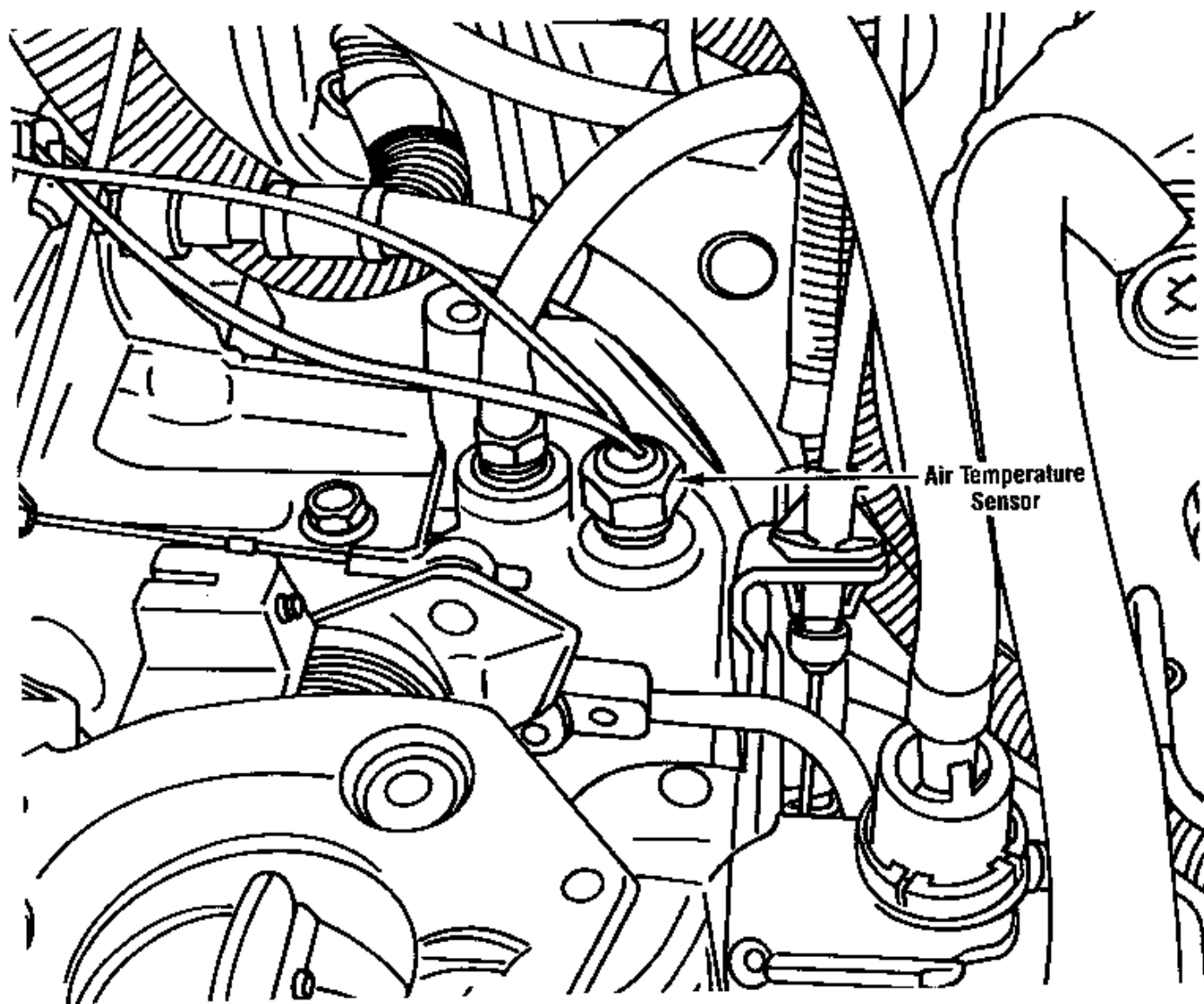


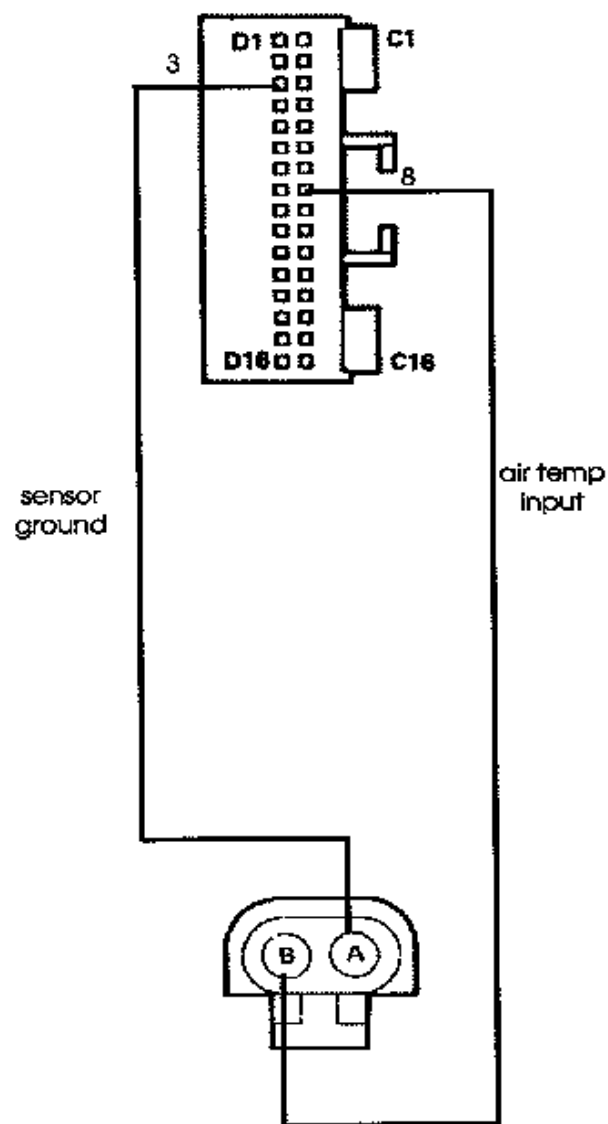
Figure 16 - Air Temperature Sensor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### AIR TEMPERATURE SENSOR CIRCUIT SCHEMATIC

ELECTRONIC CONTROL UNIT (ECU) CONNECTOR  
UNDER I/P TO RIGHT OF STEERING COLUMN



AIR TEMPERATURE SENSOR CONNECTOR  
NEXT OT THROTTLE BODY

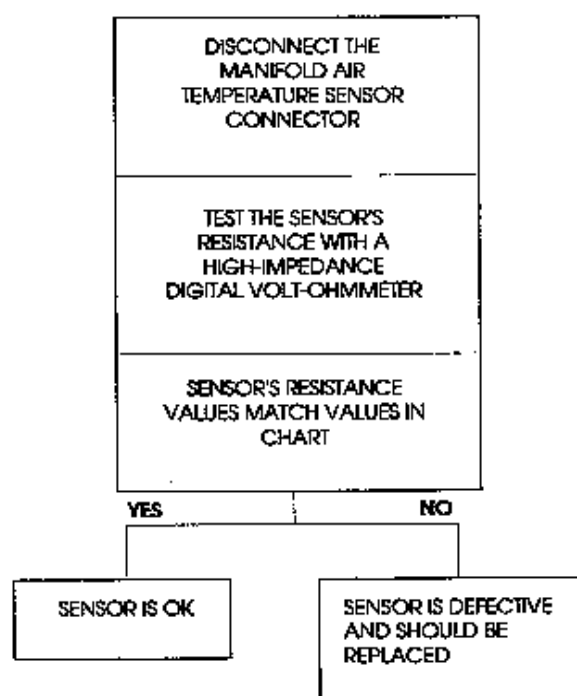
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

#### MANIFOLD AIR TEMPERATURE

##### MANIFOLD AIR TEMPERATURE SENSOR TESTING



##### MANIFOLD AIR/FUEL TEMPERATURE SENSOR

##### TEMPERATURE-TO-RESISTANCE VALUES (APPROXIMATE)

°F	°C	OHMS
212	100	185
160	70	450
100	38	1,600
70	20	3,400
40	4	7,500
20	-7	13,500
0	-18	25,000
-40	-40	100,700



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COOLANT TEMPERATURE SENSOR (Fig. 17)

The Coolant Temperature Sensor is located in the engine block cooling jacket on the left side of the engine. It provides an analog signal to the ECU. This signal is used to calculate injector pulse width when the engine is cold. Input from the coolant temperature will also affect idle speed stepper motor position, spark advance and EGR system operation.

The coolant temperature sensor is a NTC thermistor-type sensor, (internal resistance varies opposite with temperature). At cold temperatures, its resistance is high. As the temperature of the coolant increases, its resistance will decrease.

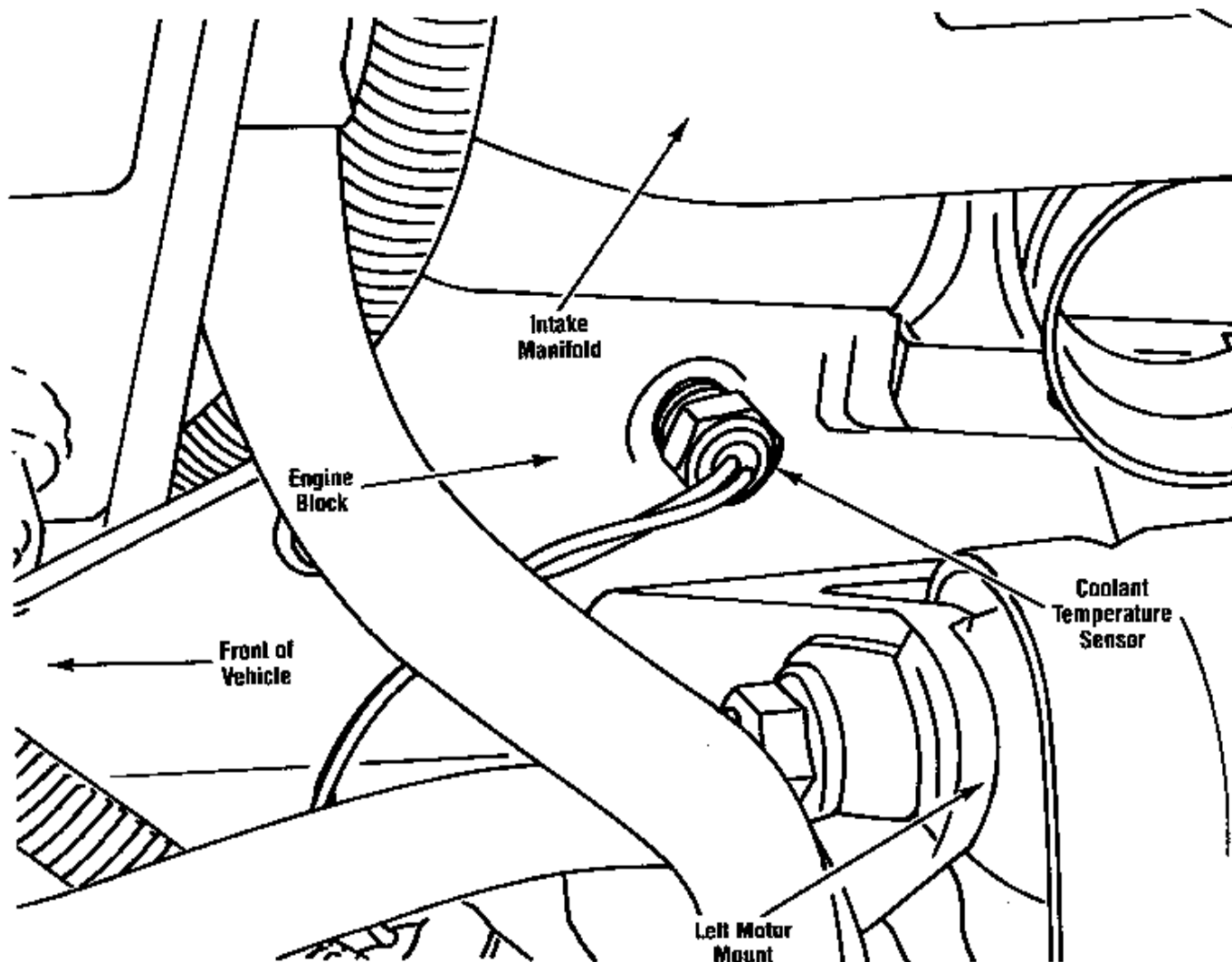


Figure 17 - Coolant Temperature Sensor

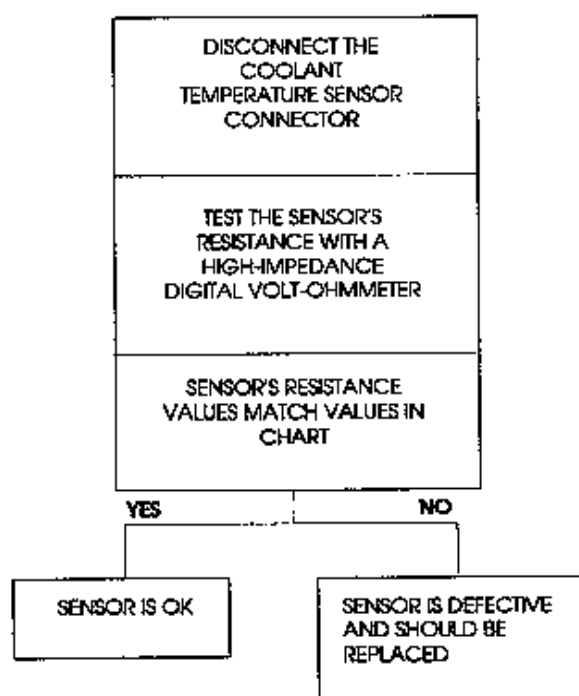
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

#### COOLANT TEMPERATURE SENSOR

##### COOLANT TEMPERATURE SENSOR TESTING



##### COOLANT TEMPERATURE SENSOR

##### TEMPERATURE-TO-RESISTANCE VALUES (APPROXIMATE)

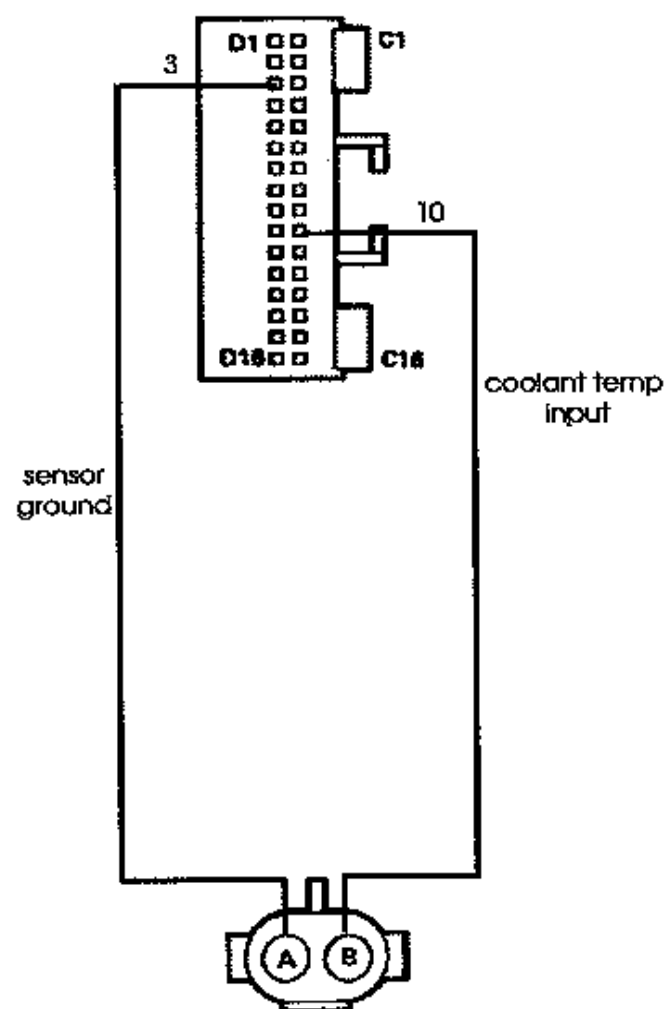
°F	°C	OHMS
212	100	185
160	70	450
100	38	1,600
70	20	3,400
40	4	7,500
20	-7	13,500
0	-18	25,000
-40	-40	100,700

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COOLANT TEMPERATURE SENSOR CIRCUIT SCHEMATIC

ELECTRONIC CONTROL UNIT (ECU) CONNECTOR  
UNDER I/P TO RIGHT OF STEERING COLUMN



COOLANT TEMPERATURE SENSOR CONNECTOR  
BEHIND LEFT HAND ENGINE MOUNT

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### THROTTLE POSITION SENSOR (TPS) (Fig. 18)

The Throttle Position Sensor is mounted on the throttle body. It contains a potentiometer operated by the opening and closing of the throttle plate. The sensor input to the ECU allows the ECU to determine precise throttle position under all operating conditions.

**NOTE:** The throttle body on an automatic transmission equipped vehicle uses a dual function throttle position sensor. This dual function sensor provides a throttle position signal for both the fuel system and the automatic transmission computers.

Procedures for adjusting the throttle position sensors on manual transmission equipped vehicles and automatic transmission equipped vehicles are different.

Power to the throttle position sensor is supplied through terminal "A" with a voltage of approximately 5.0 volts. Terminal "B" is the ground.

As the throttle plate moves, the sensor provides variable voltage signals to the ECU through terminal "C". The voltage is directly proportional to the throttle angle. When the throttle plate is closed, the voltage is low. When the throttle plate is fully open, the voltage is high. At wide open throttle, the system goes into open loop (ignores oxygen sensor activity) and interrupts the signal to the A/C clutch relay to turn off the A/C compressor clutch, (if it was on). If the proper RPM and closed throttle positions are met (hard decel), the ECU will enter a fuel cut-off strategy. The ECU will not supply power to the injectors. If a hard decel condition does not exist, the ECU determines the proper ignition pulse width and energizes each injector.

**NOTE:** A clear flood operation can be obtained by depressing the accelerator to the floor and cranking the engine. This will allow the engine to crank with out fuel delivery from the injectors.

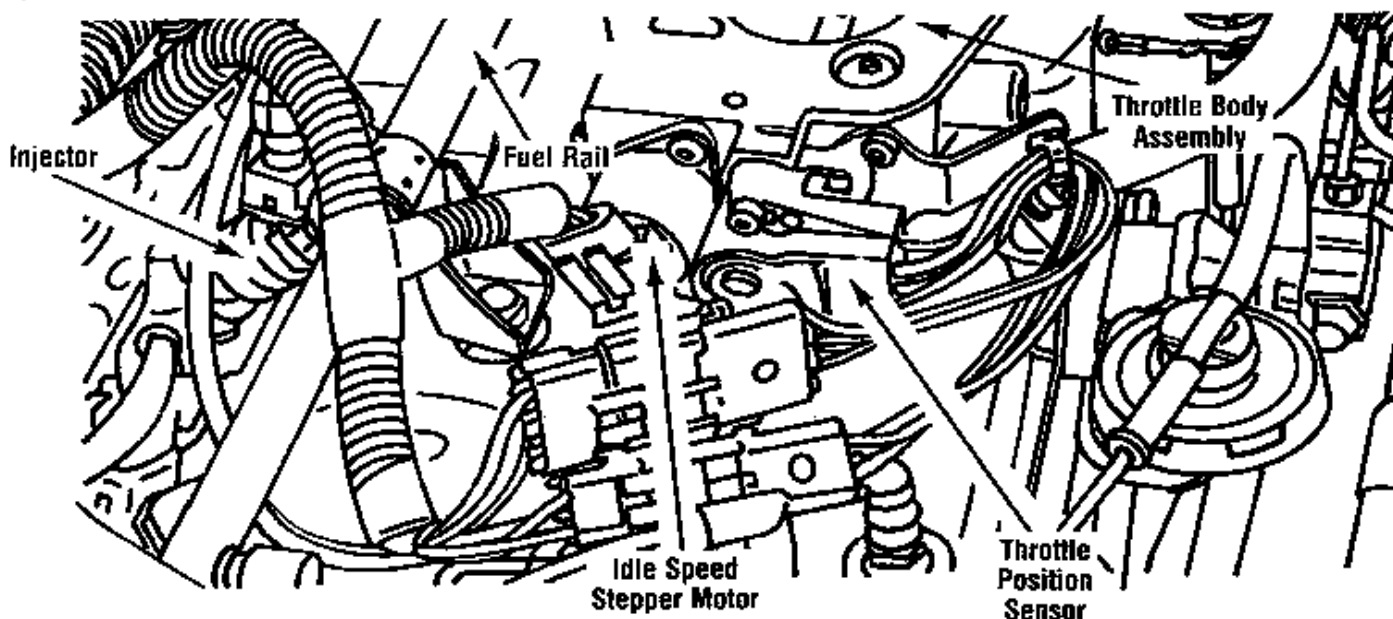


Figure 18 - Throttle Position Sensor

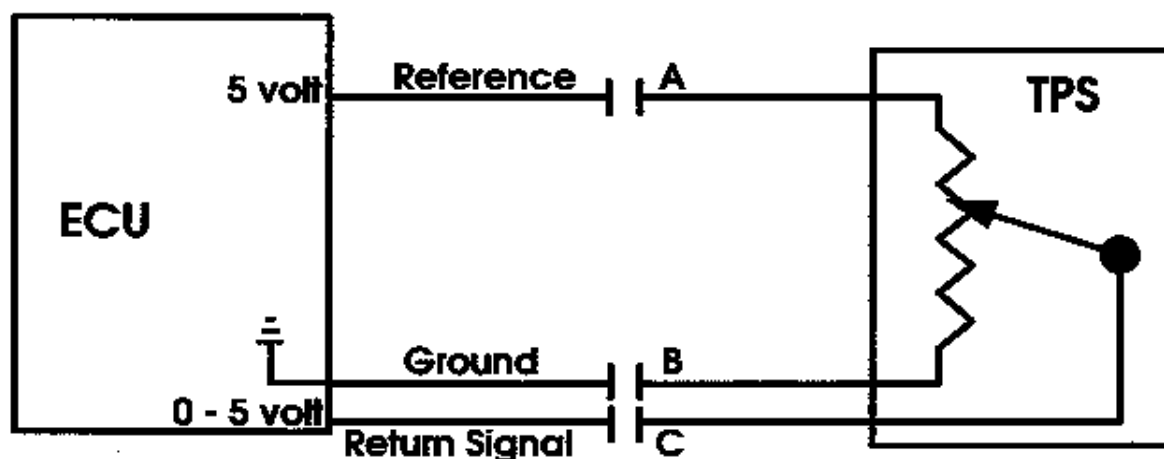
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### POTENTIOMETERS

Potentiometers are typically three-wire variable resistors that act as voltage dividers. Two wires provide a voltage and ground to a resistor element. A third wire is connected to a wiper that sweeps across the resistor between the two extreme conditions - source and ground. This wiper effectively divides the input voltage depending on its position on the resistor and provides a return signal voltage.

For Throttle Position Sensor applications, the potentiometer's wiper is mechanically connected to the throttle plate. As the throttle plate changes position, the potentiometer's wiper is moved across the resistor. Therefore, the value of the return voltage signal directly corresponds to any changes in the throttle plate's position.



Throttle Position Sensor Circuit

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

#### THROTTLE POSITION SENSOR - ADJUSTMENTS

##### MANUAL TRANSMISSION

This throttle position sensor adjustment uses a digital voltmeter. The TPS can be adjusted using the DRB II diagnostic tester, (recommended method). (Refer to the tester manual for instructions).

1. Turn the ignition key to the ON position.

Do not disconnect the sensor wire harness connector from the sensor. Insert the voltmeter test leads through the back of the wire harness connector to make contact with the sensor terminals.

2. Check the sensor input voltage. Insert the negative (-) voltmeter lead into the back of terminal B. Insert the positive (+) voltmeter lead into the back of terminal B. Be sure that the throttle plate is in the completely closed position against the idle stop. Note the input voltage.

3. Check the sensor output voltage. Remove the positive (+) voltmeter lead from sensor terminal A and insert it in the back of terminal C. Be sure the throttle is closed. Note the sensor output voltage reading on the voltmeter.

4. Divide the output voltage reading by the input reading. The desired ratio is .170. EXAMPLE: If the input voltage is 5 volts and the output voltage is .85 volts; divide .85 by 5 = .17 or 17%.

5. If necessary, adjust the TPS sensor until the correct value is obtained. To adjust input and output voltages, loosen the sensor bottom mounting screw and pivot the sensor for a large adjustment. Loosen the top sensor mounting screw and pivot the sensor for a fine adjustment. Adjust the TPS until the correct value is obtained.

6. Tighten sensor mounting screws securely. Remove the voltmeter.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

#### THROTTLE POSITION SENSOR ADJUSTMENT

##### AUTOMATIC TRANSMISSION

This throttle position sensor adjustment uses a digital voltmeter. The TPS can be adjusted using the DRB II diagnostic tester, (recommended method). (Refer to the tester manual for instructions).

For this TPS adjustment, you must use the square four terminal connector that is attached to the throttle position sensor. The terminals are marked A, B, C, and D on the connector.

1. Turn the ignition key to the ON position.

Do not disconnect the sensor wire harness connector from the sensor. Insert the voltmeter test leads through the back of the wire harness connector to make contact with the sensor terminals.

2. Check the sensor input voltage. Insert the negative (-) voltmeter lead into the back of terminal D. Insert the positive (+) voltmeter lead into the back of terminal A. Be sure that the throttle plate is in the completely closed position against the idle stop. Note the input voltage.

3. Check the sensor output voltage. Remove the positive (+) voltmeter lead from sensor terminal A and insert it in the back of terminal B. Be sure the throttle is closed. Note the sensor output voltage reading on the voltmeter. (voltage reading across terminals B and D).

4. Divide the output voltage reading by the input reading. The desired value is .415 volts. EXAMPLE: If the input voltage is 5 volts and the output voltage is 4.15 volts; divide 4.15 by 5 = .83 or 83%.
5. If necessary, adjust the TPS sensor until the correct value is obtained. To adjust input and output voltages, loosen the sensor bottom mounting screw and pivot the sensor for a large adjustment. Loosen the top sensor mounting screw and pivot the sensor for a fine adjustment. Adjust the TPS until the correct value is obtained.
6. Tighten sensor mounting screws securely. Remove the voltmeter.

## **4.0 L MULTI-POINT FUEL INJECTION SYSTEM**

### **ECU INPUTS**

#### **COMPONENT TESTING**

#### **THROTTLE POSITION SENSOR TESTING**

##### **THROTTLE POSITION SENSOR (TPS) (MANUAL TRANSMISSION)**

1. Turn ignition switch to the ON position.
2. Unplug the Throttle Position Sensor connector.
3. Measure voltage at connector pin terminal C, (harness side) with a digital voltmeter. Meter should register approximately 5 volts. If voltage is incorrect, test the vehicle using the DRB II diagnostic tester.
4. Turn the ignition switch to the OFF position.
5. Test for continuity between the throttle position sensor connector pin B and ground using a high impedance digital volt-ohmmeter. If the circuit is open, test the vehicle with the DRB II diagnostic tester.
6. Reconnect the Throttle Position Sensor connector.
7. Turn the Ignition switch to the ON position.
8. Back-probe the TPS connector with a high impedance digital volt-ohmmeter. Measure voltage from pin C to ground. Voltmeter should register approximately 0.8 volts. If voltage is incorrect, attempt to adjust the TPS using the procedures outlined in this manual or use the DRB II diagnostic tester.

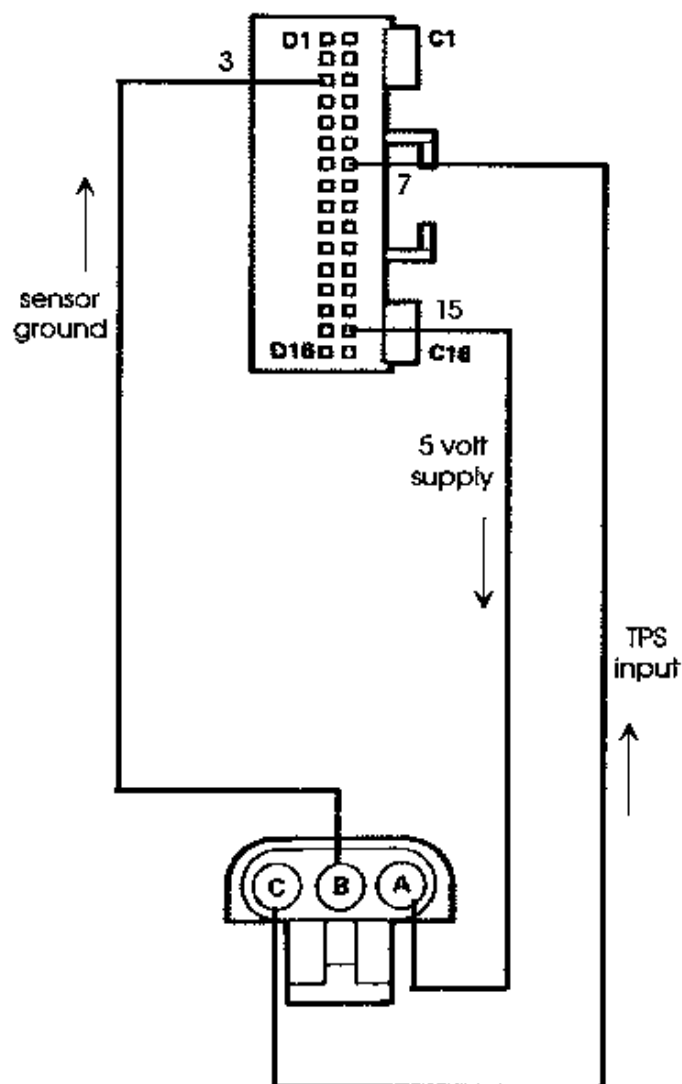


## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### THROTTLE POSITION SENSOR CIRCUIT SCHEMATIC

ELECTRONIC CONTROL UNIT (ECU) CONNECTOR  
UNDER I/P TO RIGHT OF STEERING COLUMN



THROTTLE POSITION SENSOR CONNECTOR  
NEXT TO THROTTLE BODY

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### RELAYS

##### Theory of Operation

A relay is an electro-mechanical device that consists of a coil, a resistor or a diode, and electrical contacts. The electrical contacts are held in the deenergized position by spring pressure. When voltage and ground are provided to the coil, the coil becomes an electromagnet and pulls the contacts to the energized position. When either the voltage source or the ground is removed from the coil, the magnetic field collapses and spring pressure returns the contacts to their de-energized position. The resistor or diode is included in the relay to help dissipate voltage spikes which may be produced when the coil is de-energized.

Terminal 30 is usually connected to battery voltage. This battery voltage source can be

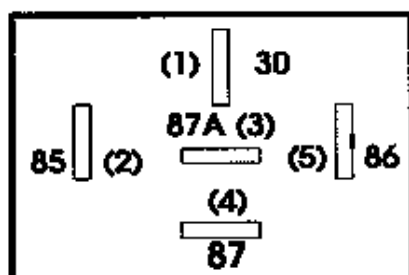
switched (ON and OFF by the ignition switch) or un-switched (connected directly to the battery).

Terminal 87A is connected to terminal 30 in the de-energized position.

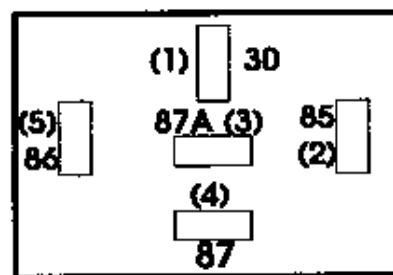
Terminal 87 is connected to terminal 30 in the energized position. Once energized, the relay supplies battery voltage to or removes battery voltage from an operated device connected to terminal 87.

Terminal 86 is connected to the electromagnet and usually connected to a switched battery voltage source.

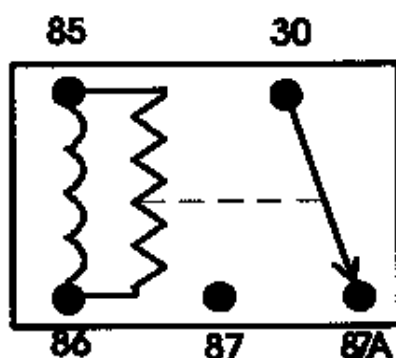
Terminal 85 is connected to the electromagnet and is usually connected to a switched or un-switched ground.



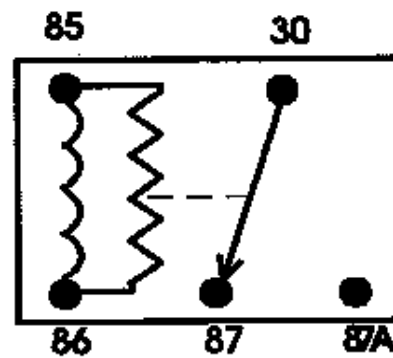
**BOTTOM VIEW OF RELAY**



**RELAY CONNECTOR**



**DE-ENERGIZED RELAY**



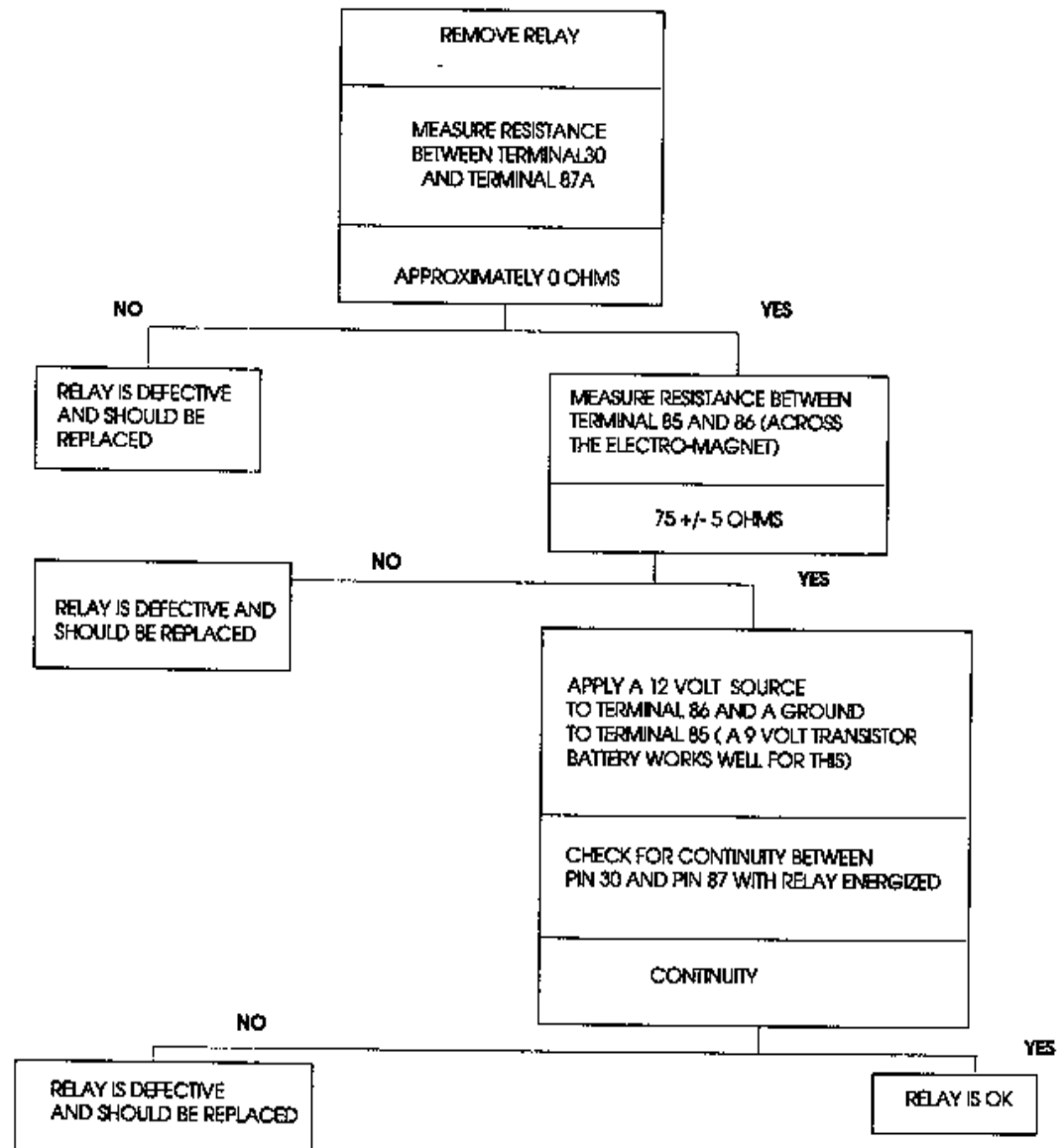
**ENERGIZED RELAY**

# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU INPUTS

### COMPONENT TESTING

#### RELAY TESTING



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### ENGINE CRANK SIGNAL (Fig. 19)

The engine crank signal from the starter relay provides a signal to the ECU to indicate when the engine starter is engaged.

When the ECU determines that the starter is engaged, it starts looking at the inputs from the speed sensor and the sync signal generator. The ECU uses these signals to determine spark timing and whether the first fuel

injection should occur at cylinder number one or cylinder number six. Once synchronization has been established, the ECU energizes the proper injector and provides the ignition output needed to start the engine.

**NOTE:** If the ECU determines that enough flywheel teeth have passed without receiving a synchronization signal, it will randomly select a sequence to start the engine.

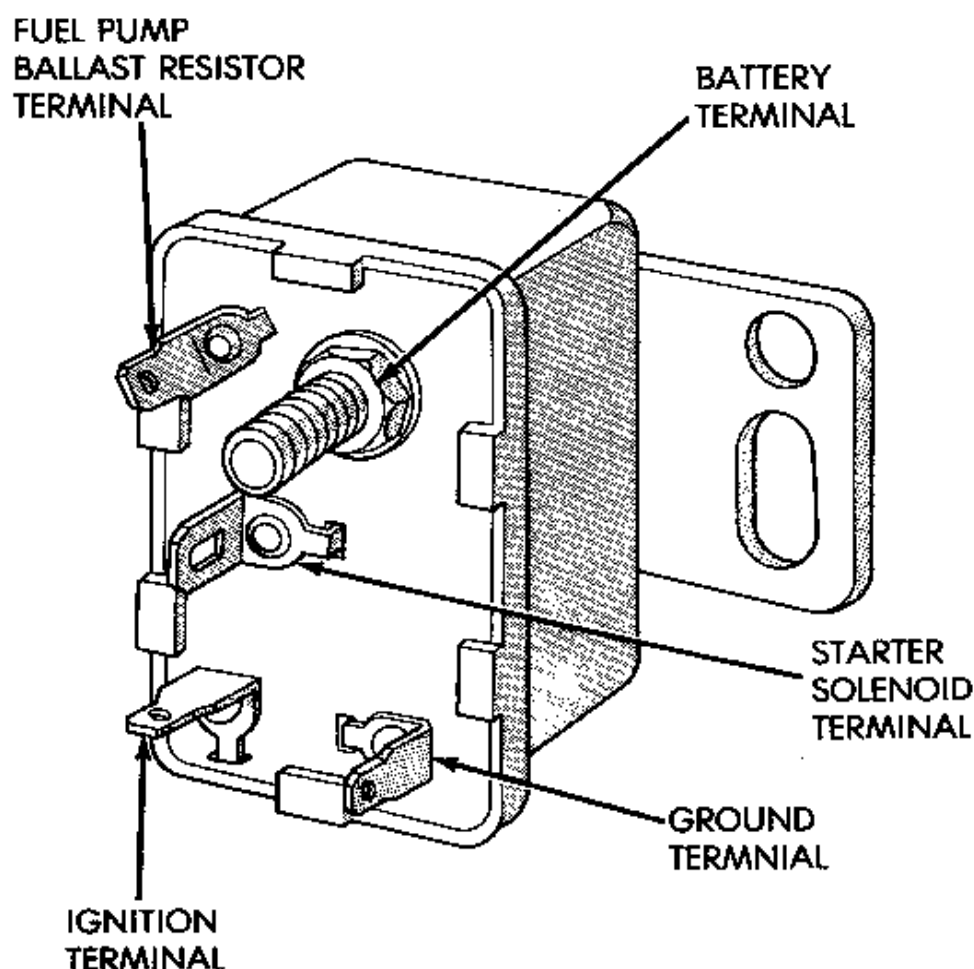


Figure 19 - Starter Relay

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### OXYGEN SENSOR (Fig. 20 & 21)

The Exhaust Gas Oxygen Sensor used on the 4.0 liter engine is NOT a voltage generating device. This sensor detects exhaust oxygen content by acting as a variable resistor. The exhaust gas oxygen sensor provides the ECU with a feedback signal. By measuring the amount of oxygen in the exhaust gases, the O2 sensor tells the ECU how well its output signals are properly controlling the air/fuel ratio. Based on this feedback, the ECU can adjust its outputs to produce the correct air/fuel ratio.

Variations in the voltage signal from the O2 sensor serve as air/fuel ratio indicators. Changes occur because the O2 sensor acts as a variable resistor. When oxygen content is low (rich mixture), the voltage signal will be less than 2.5 volts. A lean mixture (high oxygen content), the voltage signal is above 2.5 volts.

The resistance element in the O2 sensor is a small, titania semiconductor. The titania

oxygen sensor must be connected into a voltage network. A 5 volt reference is applied to a fixed resistor (located in the ECU) that is wired in series with the O2 sensor. The ECU then checks the voltage between the fixed resistor and the O2 sensor and then relates that voltage to oxygen content.

The exhaust gas oxygen sensor used on the 4.0 liter engine contains a heater in the sensor housing. The heater is a ceramic, resistance-type element that operates on 12 volts supplied through a relay controlled by the ECU. The heater is needed to maintain the titania semiconductor at its operational temperature of approximately 1475 degrees F. (850 degrees C.)

The oxygen sensor heater relay is controlled by the ECU. When the ECU determines high exhaust gas rates and exhaust gas oxygen sensor heating is no longer required, the ECU completes the relay coil ground circuit. When the ground circuit is complete, the relay contacts open, and the exhaust gas oxygen sensor heater is disabled.

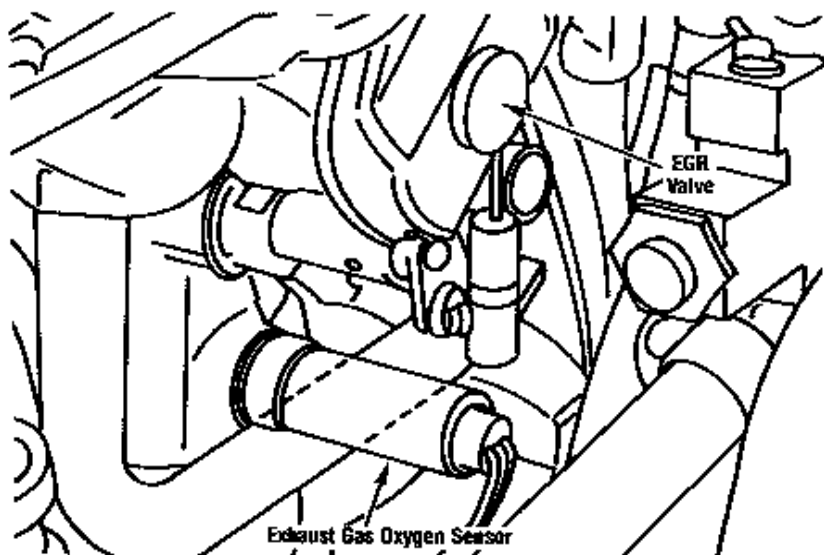


Figure 20 - Exhaust Gas Oxygen Sensor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### COMPONENT TESTING

#### EXHAUST GAS OXYGEN SENSOR TESTING

##### EXHAUST GAS OXYGEN SENSOR

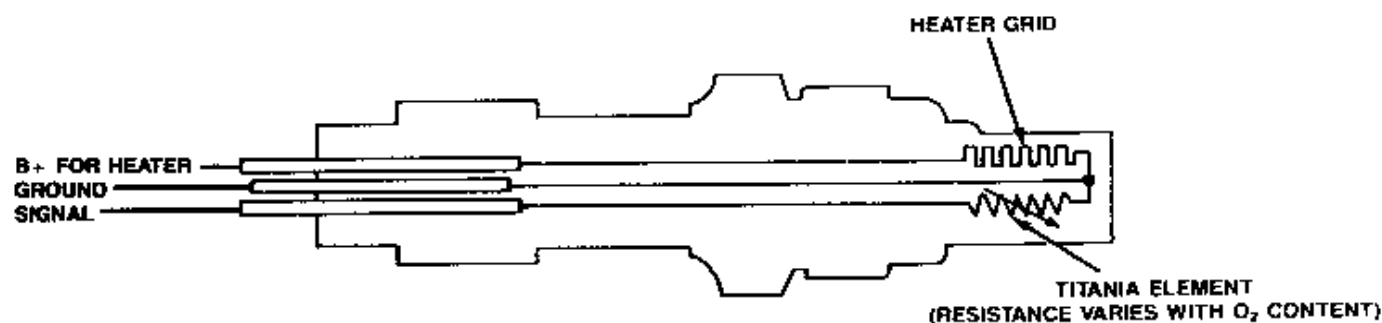
The DRB II Diagnostic tester, Jeep/Eagle adaptor and the Powertrain Diagnostic manuals must be used to test Exhaust Gas Oxygen Sensor operation.

##### OXYGEN SENSOR HEATING ELEMENT TEST

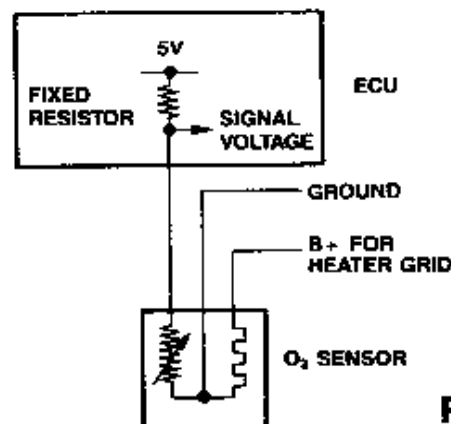
The oxygen sensor heating element can be tested by using an ohmmeter.

1. Disconnect the Oxygen Sensor connector
2. Connect the ohmmeter test leads between terminals A and B of the oxygen sensor connector.

The resistance value should be between 5 and 7 ohms. Replace the sensor if ohmmeter displays an infinite reading.



Heated Titania Oxygen Sensor



EXHAUST O<sub>2</sub> CONTENT  
O<sub>2</sub> SENSOR RESISTANCE  
VOLTAGE DROP ACROSS FIXED RESISTOR  
SIGNAL VOLTAGE

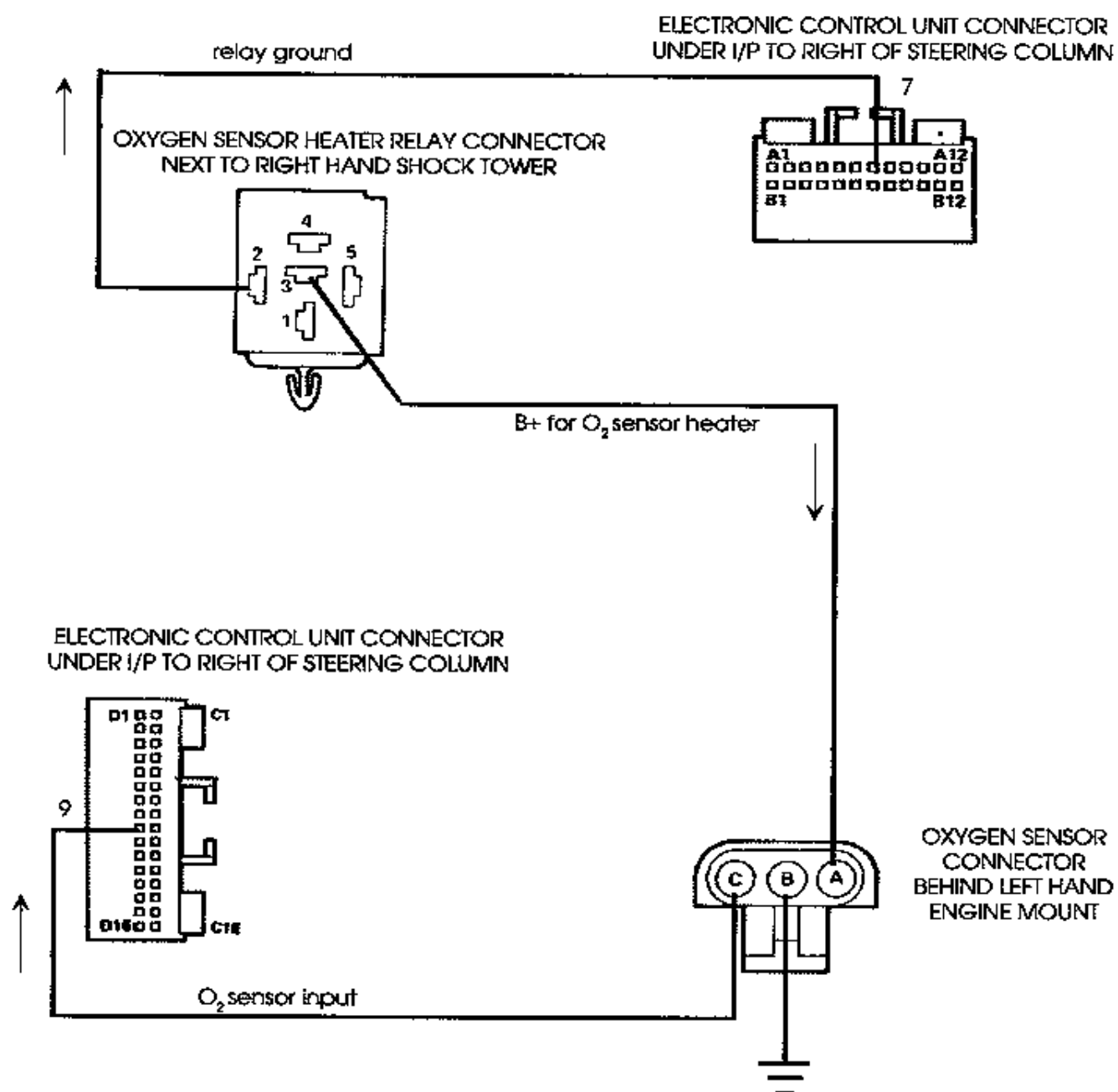
	ENGINE LEAN	ENGINE RICH
EXHAUST O <sub>2</sub> CONTENT	↑	↓
O <sub>2</sub> SENSOR RESISTANCE	↑	↓
VOLTAGE DROP ACROSS FIXED RESISTOR	↓	↑
SIGNAL VOLTAGE	↓	↑

Figure 21 - Voltage Network

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### EXHAUST GAS OXYGEN SENSOR CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### KNOCK SENSOR (Fig. 22)

The Knock Sensor is threaded into the left side of the engine block. It provides a signal to the ECU that indicates any knock present during engine operation. The knock sensor is made up of a thin piezo-electric ceramic disc bonded to a metal diaphragm, when knock occurs, the diaphragm vibrates along with the piezo-electric disc, producing an electrical signal.

As the intensity of vibrations increase, the voltage from the knock sensor also increases. Based on this voltage, the ECU can determine if an engine knock is present. If a knock is present, the ECU will retard ignition timing by a predetermined value on any one cylinder or a combination of cylinders. After 10 to 15 seconds, the ignition timing will progressively return to its value prior to when the spark knock was detected.

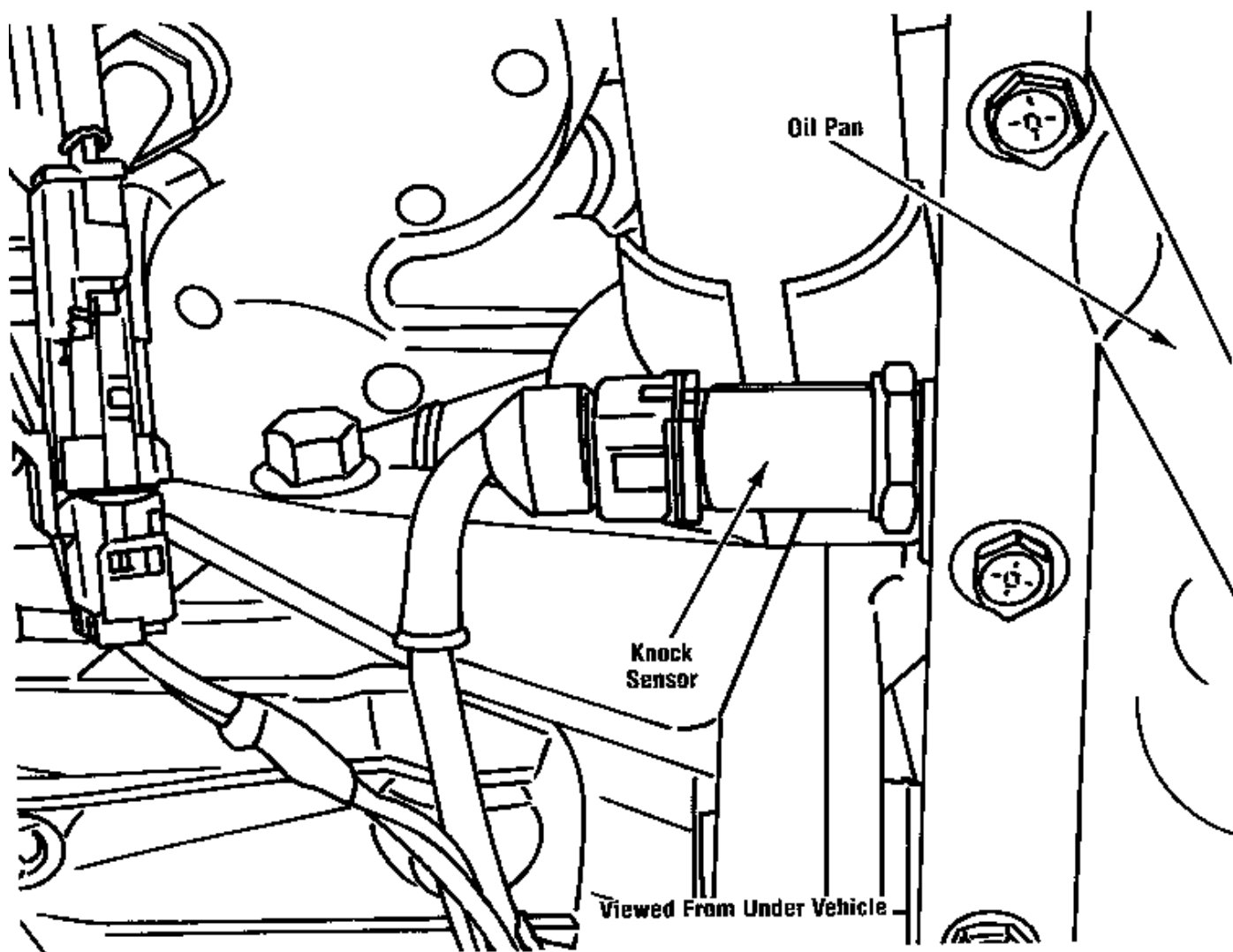


Figure 22 - Knock Sensor



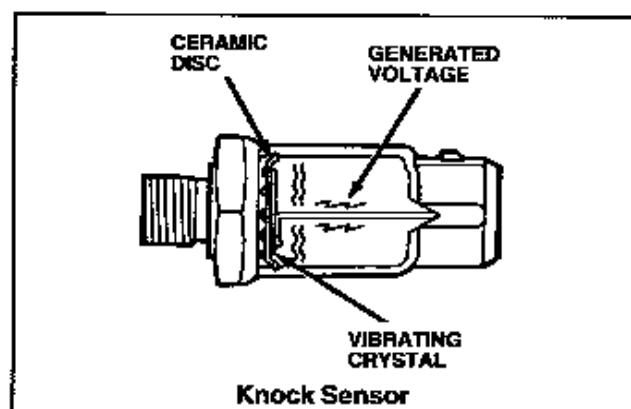
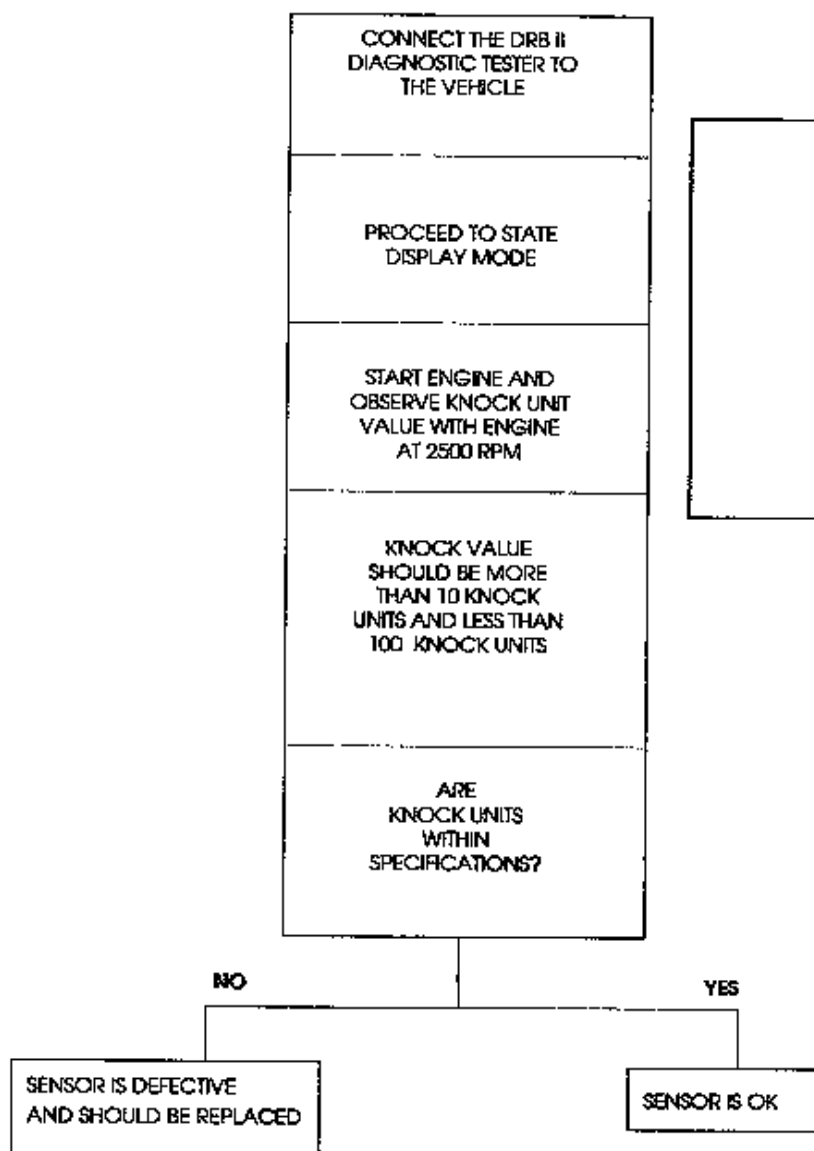
# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU INPUTS

### COMPONENT TESTING

#### KNOCK SENSOR

##### KNOCK SENSOR TESTING

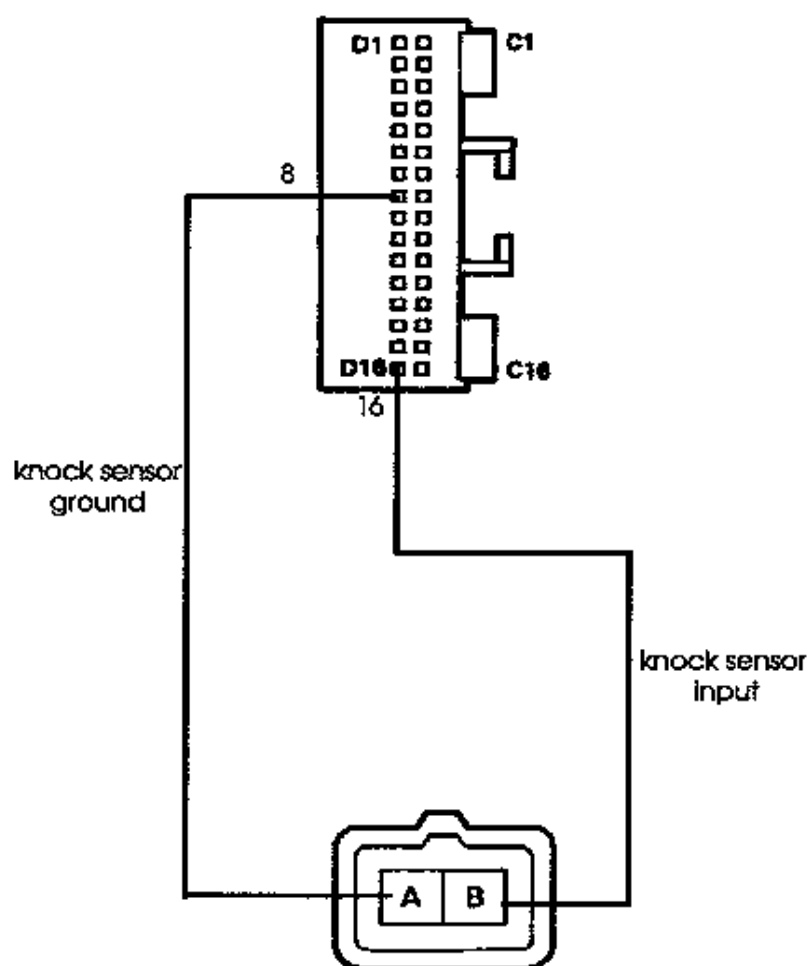


## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### KNOCK SENSOR CIRCUIT SCHEMATIC

ELECTRONIC CONTROL UNIT (ECU) CONNECTOR  
UNDER I/P TO RIGHT OF STEERING COLUMN



KNOCK SENSOR CONNECTOR  
BEHIND LEFT HAND ENGINE MOUNT  
JUST ABOVE THE OIL PAN

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU INPUTS

#### AIR CONDITIONING SELECT SIGNAL

This input provides a signal to indicate when the air conditioning switch is activated by the driver. This information is used by the ECU to determine the idle speed.

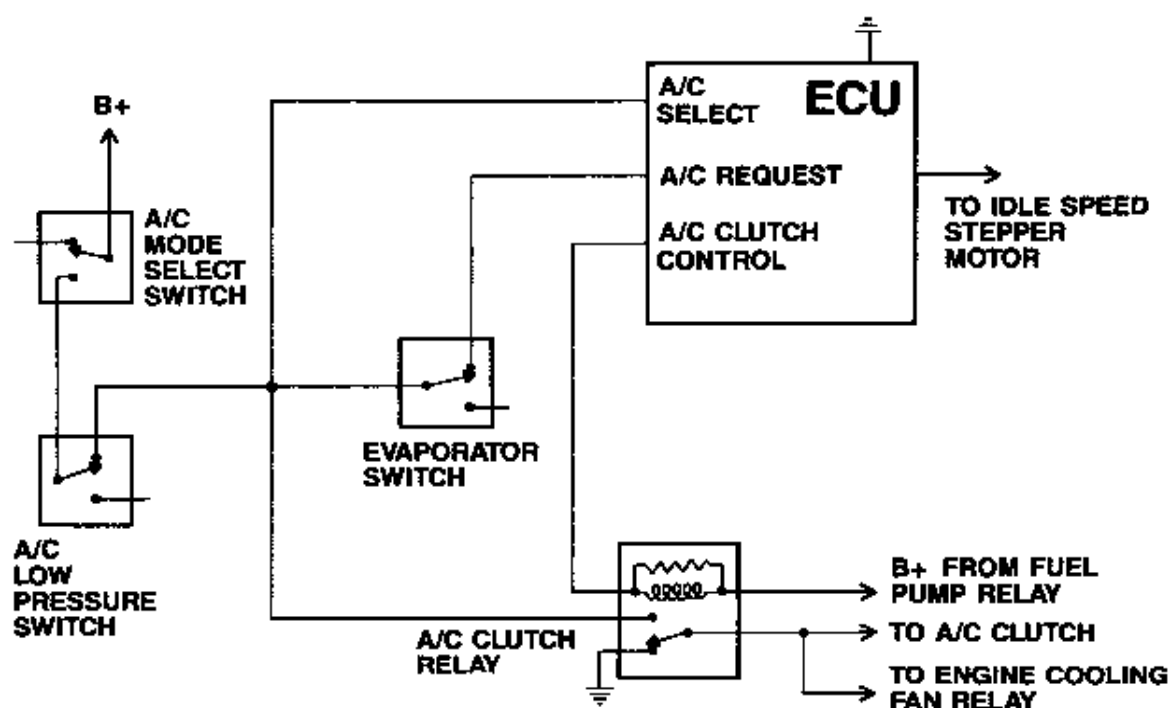
#### AIR CONDITIONING REQUEST SIGNAL

After the driver has selected air conditioning, the air conditioning request signal provides information the ECU from the air conditioning thermostat (evaporator switch). This signal indicates that the evaporator temperature is in an acceptable range for air conditioning application.

This information is used by the ECU to determine the required idle speed stepper motor position and to activate or deactivate the air

conditioning clutch. When the ECU receives an air conditioning request signal, it repositions the idle speed stepper motor to increase idle speed. The increased idle speed compensates for the additional engine load caused by the A/C compressor.

**NOTE:** Whenever the ECU receives the A/C select and request signals, the ECU energizes the electric cooling fan by energizing the A/C clutch relay - thus sending system voltage to the A/C clutch and the engine cooling fan relay. Under these conditions, the cooling fan relay is closed regardless of engine temperature.



## **4.0 L MULTI-POINT FUEL INJECTION SYSTEM**

### **ECU INPUTS**

#### **GEAR INDICATOR SIGNALS**

On vehicles with automatic transmissions, a gear indicator signal is sent to the ECU when the gear selector lever has been moved to a drive range. This signal comes from the neutral safety switch and allows for idle speed compensation by the ECU. Manual transmissions do not provide a gear indicator signal to the ECU.

## **4.0 L MULTI-POINT FUEL INJECTION SYSTEM**

### **ECU OUTPUTS**

#### **ECU OUTPUTS**

Based upon information received from the various sensors, the ECU controls the following components:

- Fuel Injectors
- Fuel Pump Relay
- Idle Speed Stepper Motor
- Power Latch Relay
- Oxygen Sensor Heater Relay
- EGR Solenoid
- Ignition Power Module
- Shift Indicator Light
- Air Conditioning Clutch Relay

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### FUEL PUMP RELAY (Fig. 23)

The fuel pump relay is located on the right innerfender panel. The feed side of the relay coil is powered by the Ignition switch. The relay is energized by the ECU by grounding the other side of the coil. The relay contacts are normally open and will close when the ECU provides a ground path for the relay coil. Battery voltage to the relay coil is supplied from the Ignition switch I-1 terminal. Battery voltage through the relay contacts originates at a power splice that is connected directly to the battery through a fusible link located at the starter relay.

The fuel pump circuit is completed during cranking and whenever the engine is running. If the ignition key is turned to the "run" position, the pump will operate for one to three seconds and then shut off. If the ECU does not receive a crank or run signal, it deactivates the pump by opening the relay coil ground circuit. The one to three second time limit is used to prevent unnecessary operation of the pump once the system is pressurized. If the engine were running, the

ECU would maintain the coil ground allowing continuous operation of the pump.

The fuel pump relay is an electro-mechanical switch used to connect the electric fuel pump to battery voltage. Inside, the relay contains a coil and a set of electrical contacts. Externally, the coil and contacts are connected to the battery, ignition switch, Electronic Control Unit (ECU) and the fuel pump.

When connected to the battery through the ignition switch and to ground through the ECU, the coil becomes an electro-magnet. The magnetic field generated by the coil attracts and moves the relay armature. Movement of the armature closes the relay contacts. When the contacts close, the battery circuit to the pump is complete and the pump operates. When the ECU opens the relay coil circuit, the magnetic field collapses and spring pressure opens the relay contacts.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

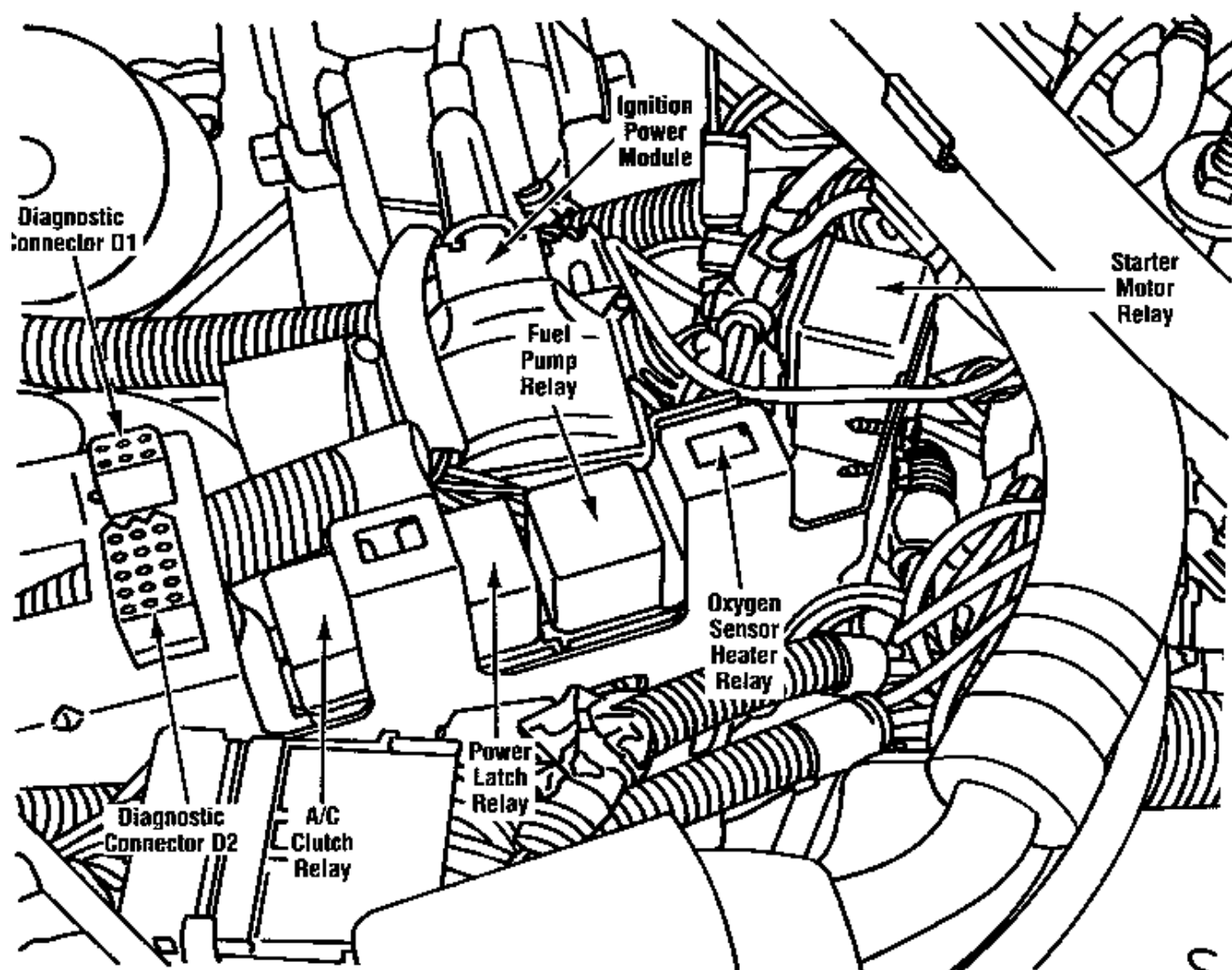
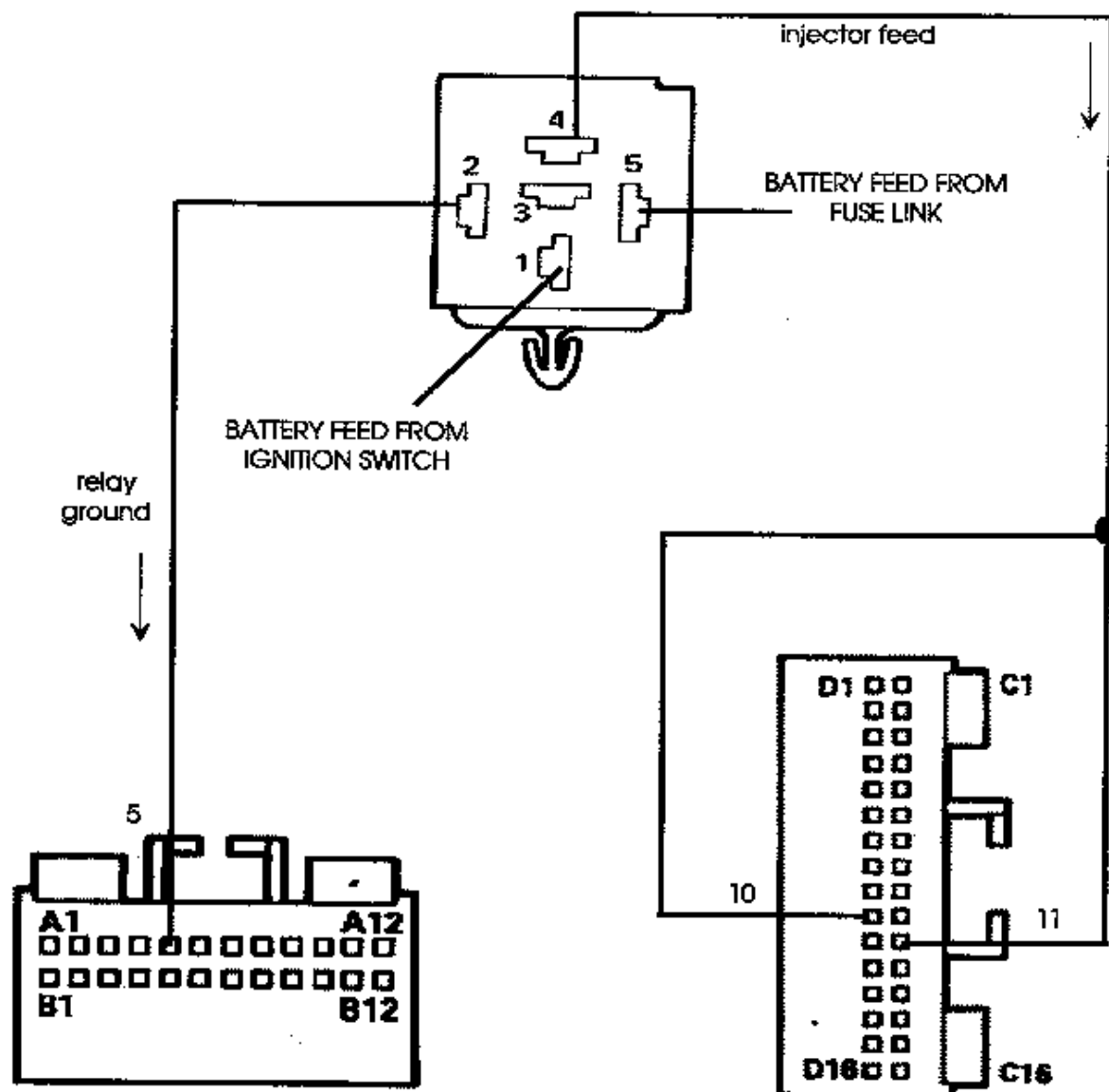


Figure 23 - Fuel Pump Relay

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### FUEL PUMP RELAY CIRCUIT SCHEMATIC



ELECTRONIC CONTROL UNIT (ECU) CONNECTORS  
UNDER I/P TO RIGHT OF STEERING COLUMN



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### POWER LATCH RELAY (Fig. 24)

The system power latch relay is located on the right-hand inner fender. The power latch relay is energized during key on and continues to be energized by the ECU for 3 to 5 seconds after the key has been turned off. The time delay allows the ECU to reposition the idle speed stepper motor in anticipation of the next start up. The ECU then disengages the power latch relay.

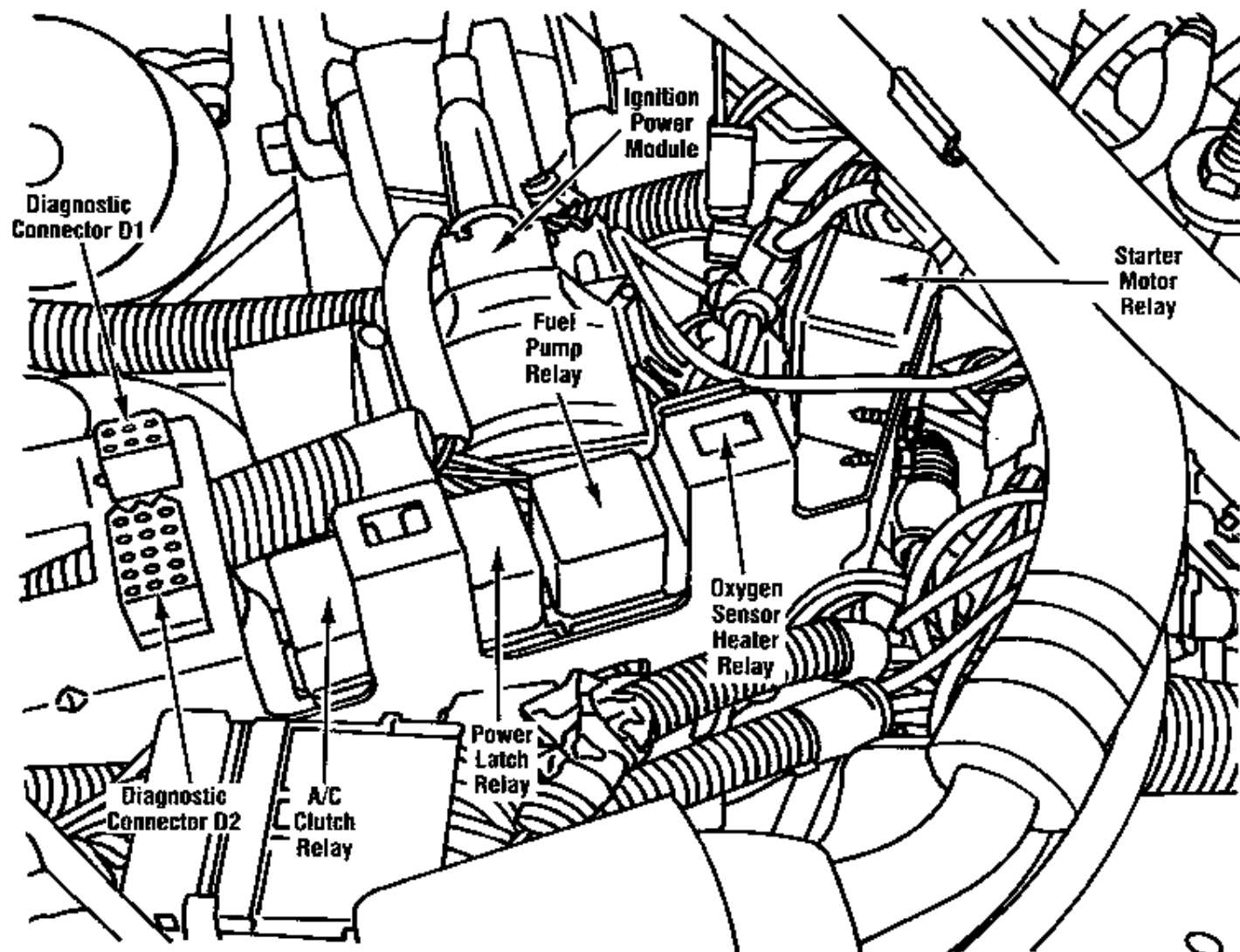
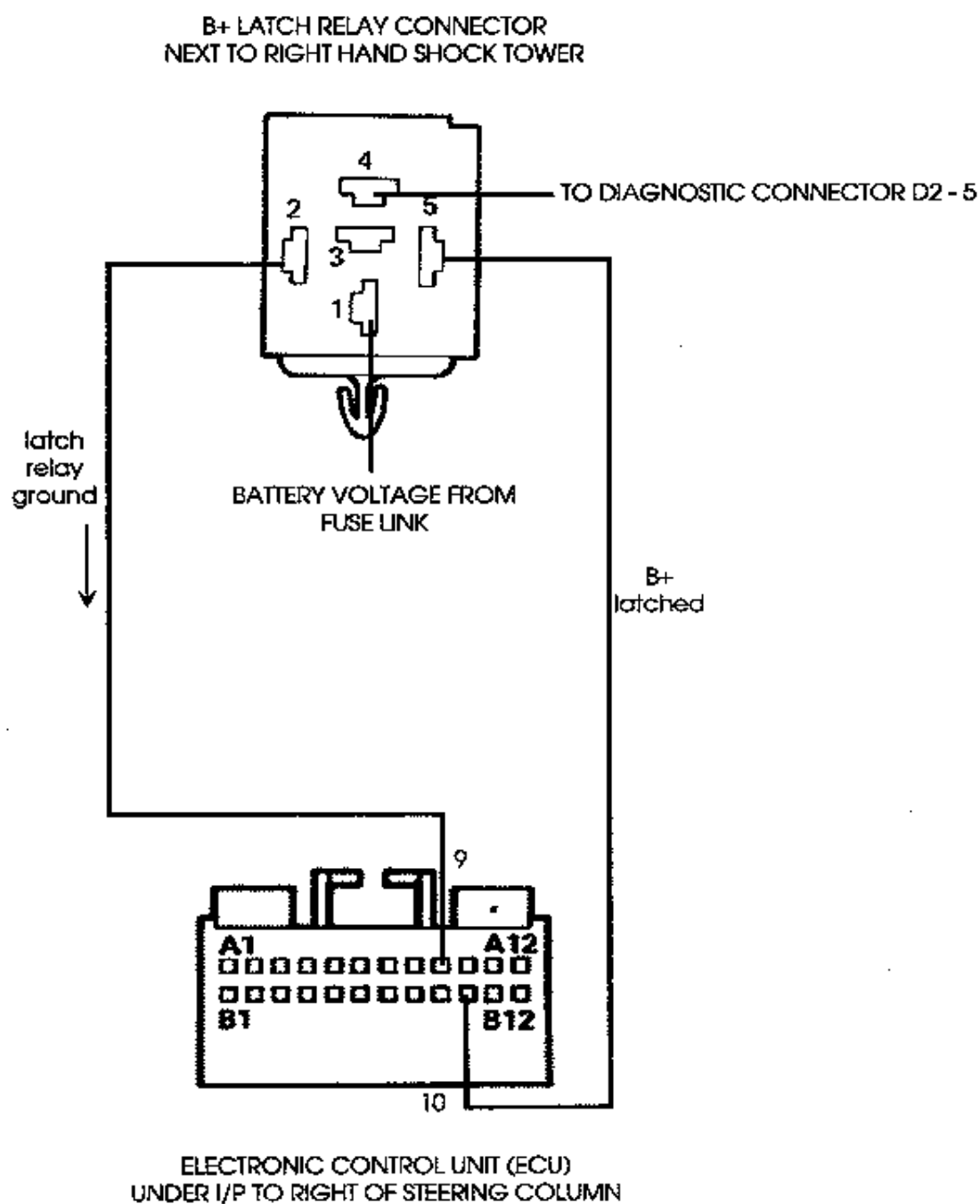


Figure 24 - Power Latch Relay

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### POWER LATCH RELAY CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### FUEL INJECTORS (Fig. 25)

The fuel injectors are mounted on the intake manifold. They are controlled electronically and exclusively by the ECU. Because each injector is connected to a permanent ground, the injector is energized when connected to battery voltage through the ECU. The ECU also controls the amount of time the injector is energized. This is referred to as "pulse width". Pulse width is based on various inputs and calculated by the ECU. The six fuel injectors are energized in a specific sequence, or firing order, by the ECU.

With the injector connected to a pressurized fuel supply, a fine mist will spray from the injector nozzle into the intake manifold. The injector uses electro-magnetism and spring pressure to open and close the fuel metering plunger. When connected to battery voltage, the coil of wire in the injector becomes

an electromagnet. The magnetic field generated in the coil is sufficient to raise the plunger off its seat against spring pressure. When the injector circuit is opened by the ECU, the magnetic field will collapse and spring pressure forces the plunger against its seat.

Whenever an injector is opened, it will always spray a consistent amount of fuel for a given amount of pressure. Because the pressure drop across the injector is fixed and the fuel flow rate is constant, the only remaining variable is the amount of time the injector is open and spraying fuel. By controlling the time the injector is open (pulse width), the ECU can provide the smaller amount of fuel for engine idle or it can increase pulse width to meet maximum fuel demand situations such as wide open throttle.

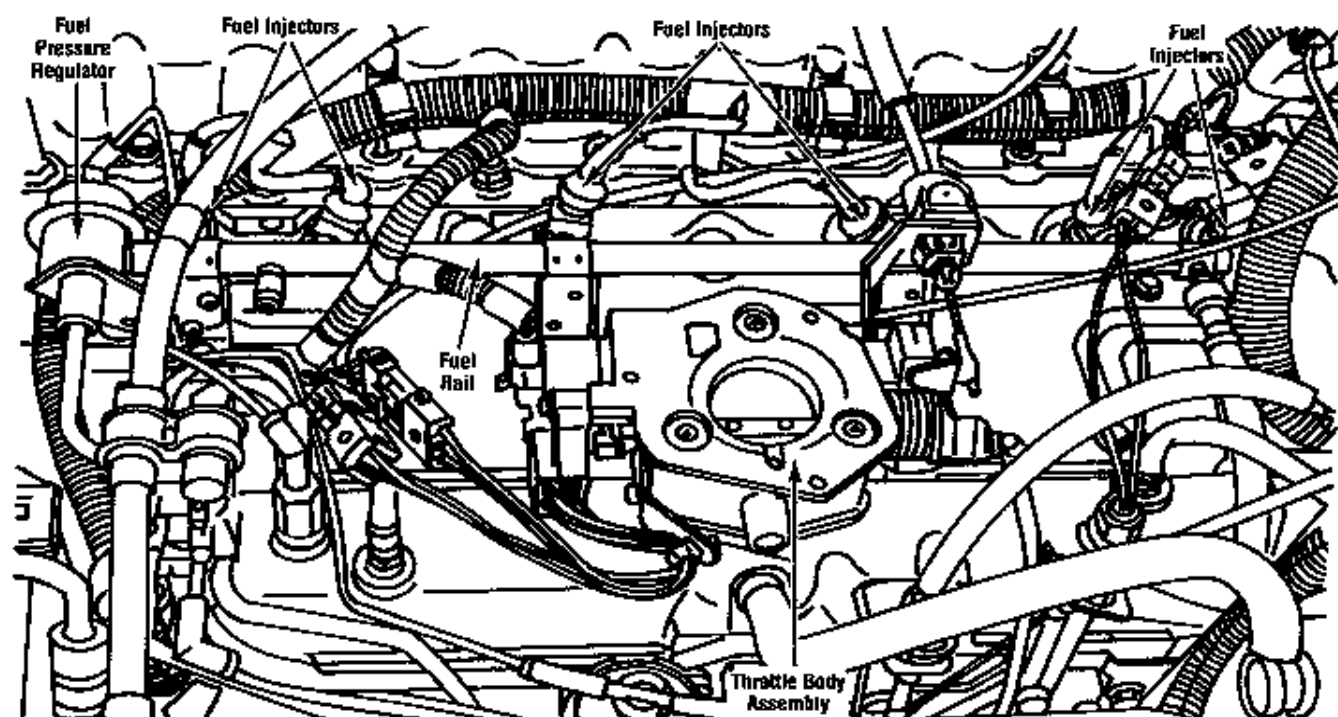
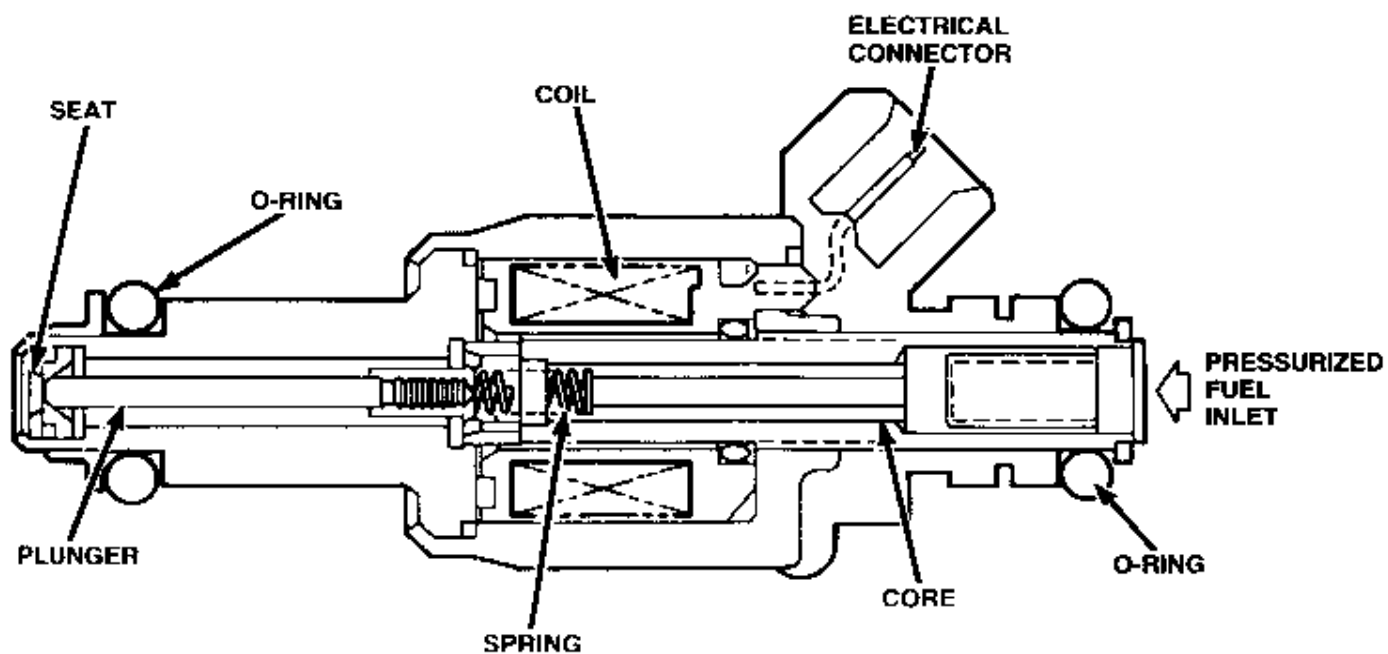


Figure 25 - Fuel Injectors

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS



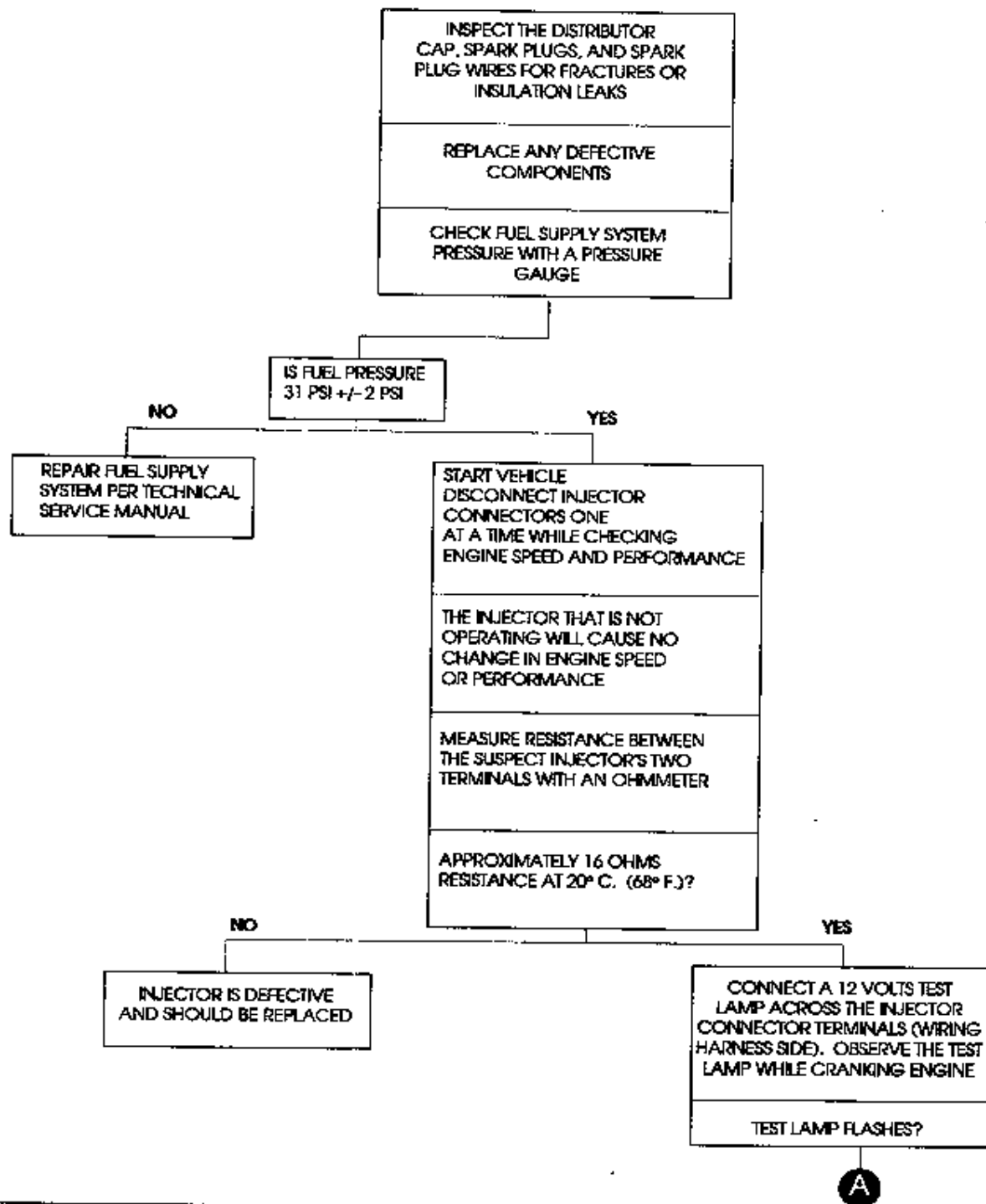
**Fuel Injector Cut-a-way View**

# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU OUTPUTS

### COMPONENT TESTING

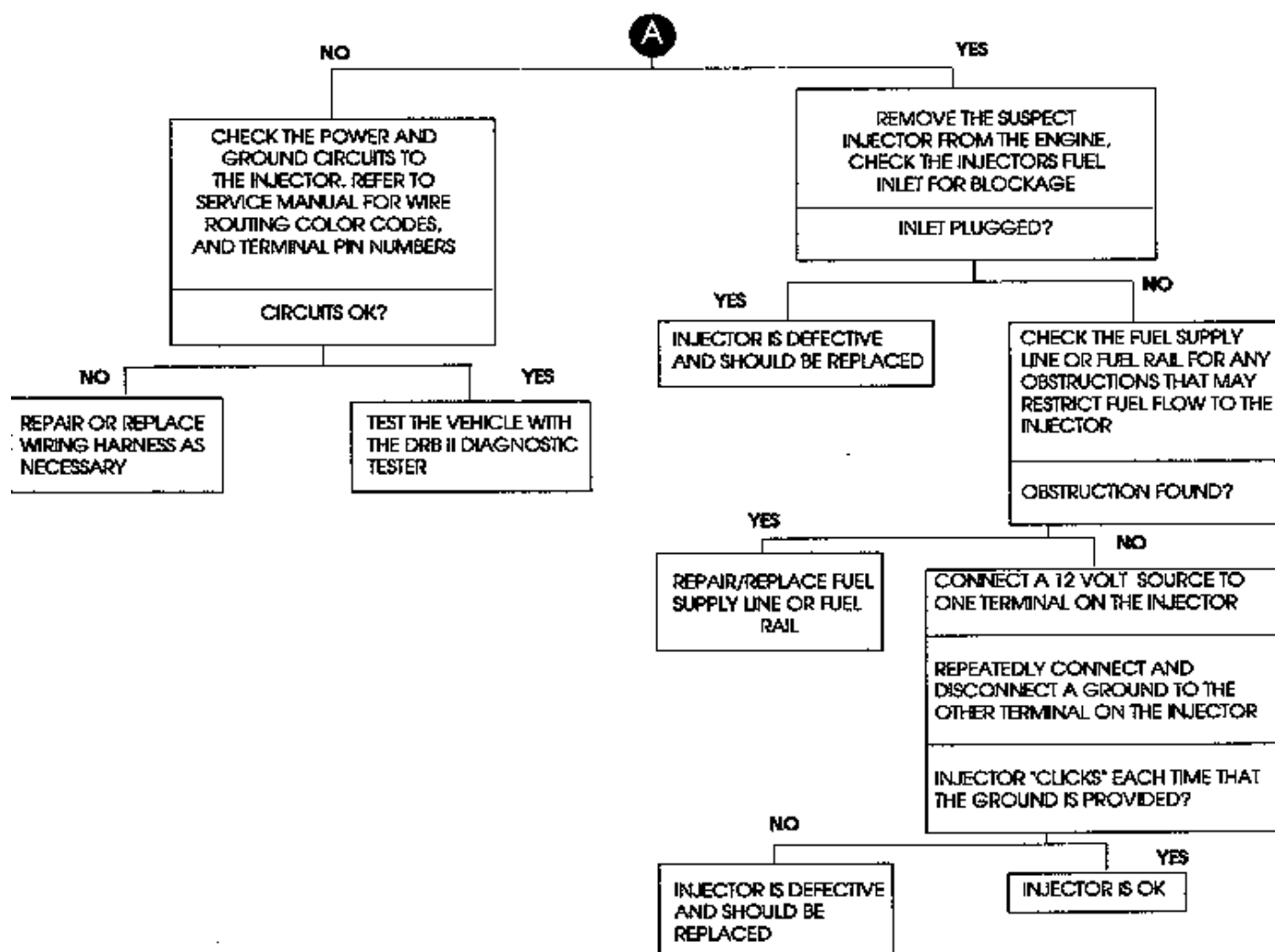
#### FUEL INJECTOR DIAGNOSIS AND TESTING



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## ECU OUTPUTS

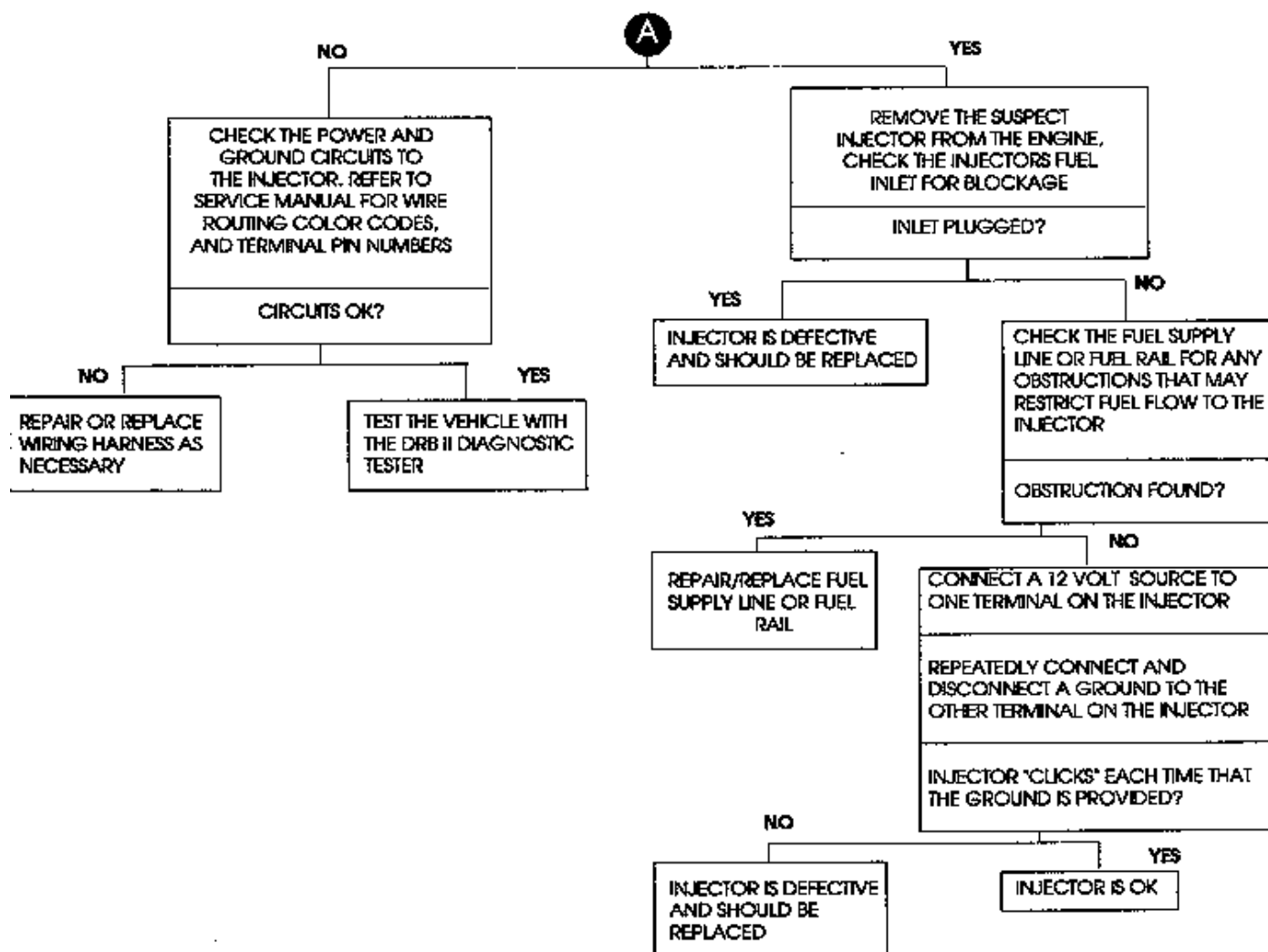
### FUEL INJECTOR DIAGNOSIS AND TESTING



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### FUEL INJECTOR DIAGNOSIS AND TESTING



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### INJECTION TIMING (Fig.26)

The 4.0 liter fuel injection system is sequential. The term sequential means the injectors have a specific firing order and fuel injection is timed to piston movement. Although its a fuel system, sequential injection is more easily understood if it is compared to an ignition system. Ignition timing matches spark plug firing to piston position and spark plugs are fired in a specific order. In fact, on the 4.0 liter engine, the spark plugs and fuel injectors are fired in the same order - 1-5-3-6-2-4.

In order for the ECU to fire the injectors in a specific order timed to crankshaft and piston movement, it has to establish a reference point. Establishing the reference point requires ECU inputs from the speed sensor and the sync signal generator.

The speed sensor located on the transmission bellhousing, provides the ECU with crankshaft angle and speed. The ECU converts crankshaft speed into engine rpm and crankshaft angle into piston position. The toothed

flywheel, rotating past the speed sensor, contains three notches 120 degrees apart. Each notch is separated by twenty teeth and is used to locate the position of two of the pistons.

**NOTE:** Speed Sensor operation is detailed in the ECU INPUT section of this book.

Pistons one and six approach TDC at the same time and use the same flywheel notch. Piston two is matched with piston five while piston three is matched with piston four. From the speed sensor, the ECU knows two pistons are approaching TDC. What it does not know is which pair of pistons is approaching TDC. The sync signal generator provides this information.

**NOTE:** The notches are located on the flywheel to relate precise piston position to the ECU. When one of the notches passes the speed sensor, the ECU is informed that the position of a particular set of pistons - such as 1 and 6 - is 60 degrees before top dead center. The twelfth tooth after the notch is top dead center.

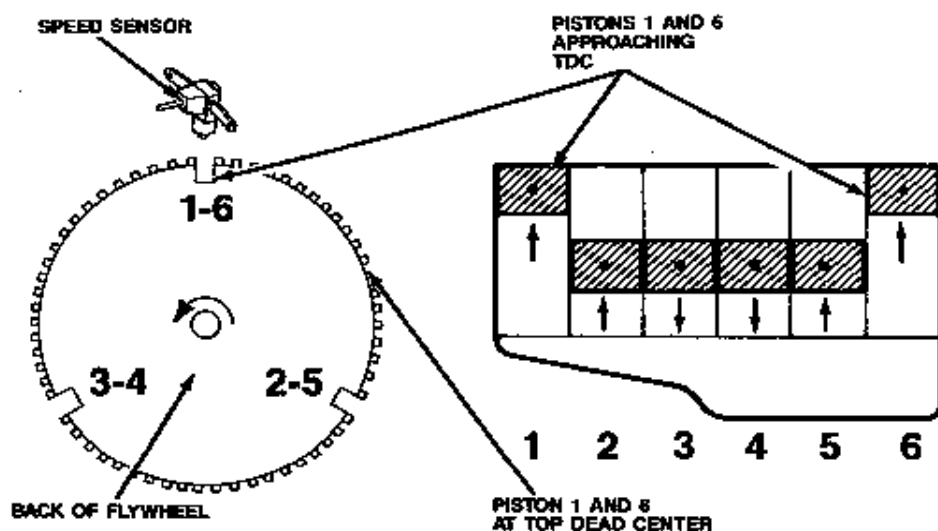


Figure 26 - Injection Timing



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### IGNITION POWER MODULE (Fig. 27)

The ECU receives inputs from the appropriate sensors. Based on this information, it then determines the proper ignition timing and provides the ignition power module (located on the right inner fender) with the signal to

trigger the ignition coil. The ECU calculates and controls all ignition operation. If spark knock is detected, the ECU will vary spark timing on a single cylinder or a combination of cylinders. Once the knock has been eliminated the ECU will progressively return timing to the setting prior to when knock occurred.

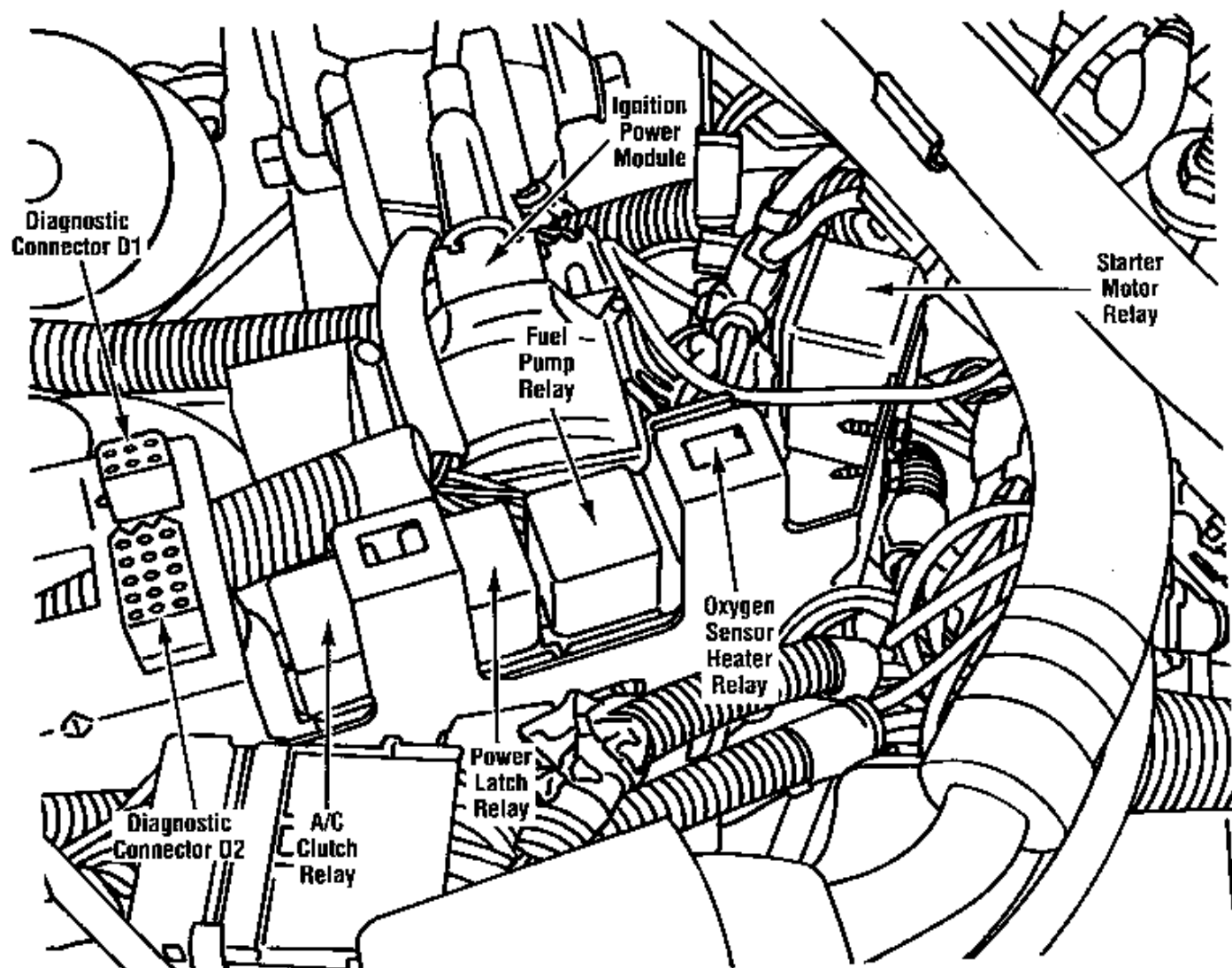
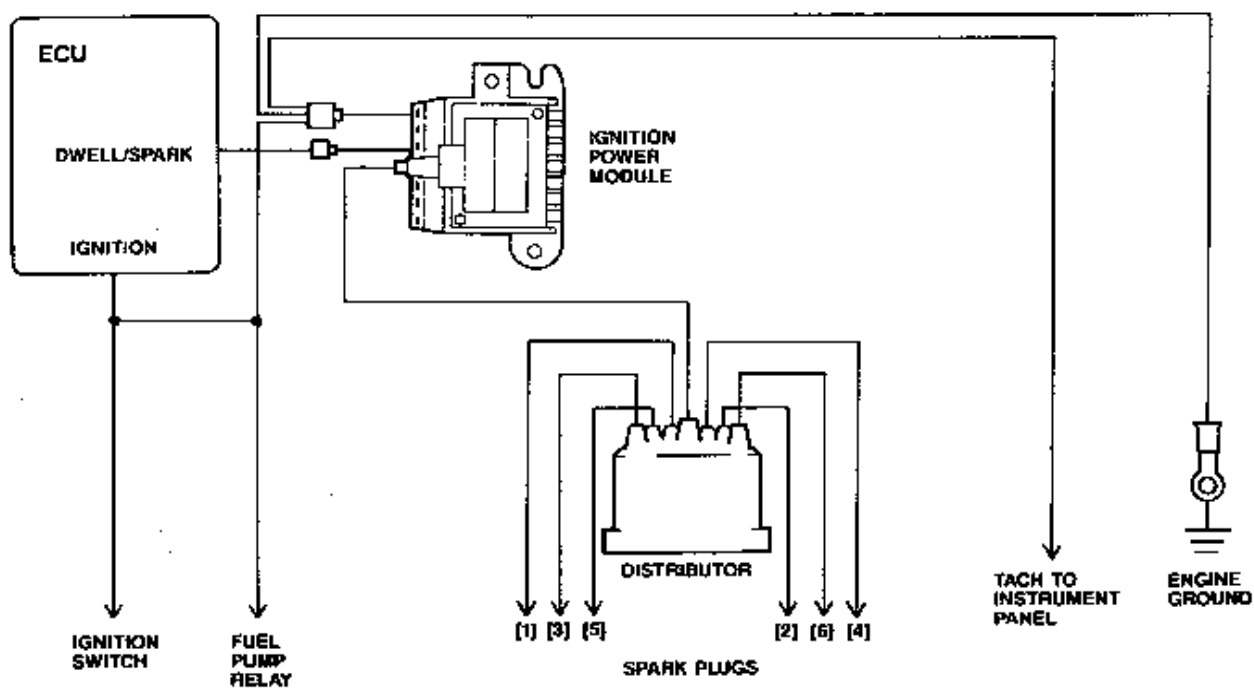


Figure 27 - Ignition Power Module

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### IGNITION POWER MODULE CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### EGR SOLENOID (Fig. 28)

The EGR Solenoid is located on the left inner fender panel. The EGR solenoid valve is an electro-mechanical device that consists of an electro-magnet, a vacuum passage, and a valve. With key "ON", the EGR solenoid valve receives constant battery voltage. During engine conditions in which EGR is not desired (warm up, idle, wide open throttle, and rapid acceleration/deceleration), the ECU provides the EGR solenoid valve with a ground. With a voltage source and ground provided to the electro-magnet, the solenoid is energized, the valve is pulled closed, and vacuum is not permitted to reach the EGR valve. SOLENOID ON = EGR OFF.

During engine conditions in which EGR is desired (warm cruise), the ECU opens the ground circuit. With the ground circuit open, the electromagnet is de-energized, the valve opens, and the vacuum is applied to the EGR valve. SOLENOID OFF = EGR ON.

**NOTE:** If the EGR solenoid electrical connector becomes disconnected, vacuum to the EGR valve will be supplied all the time.

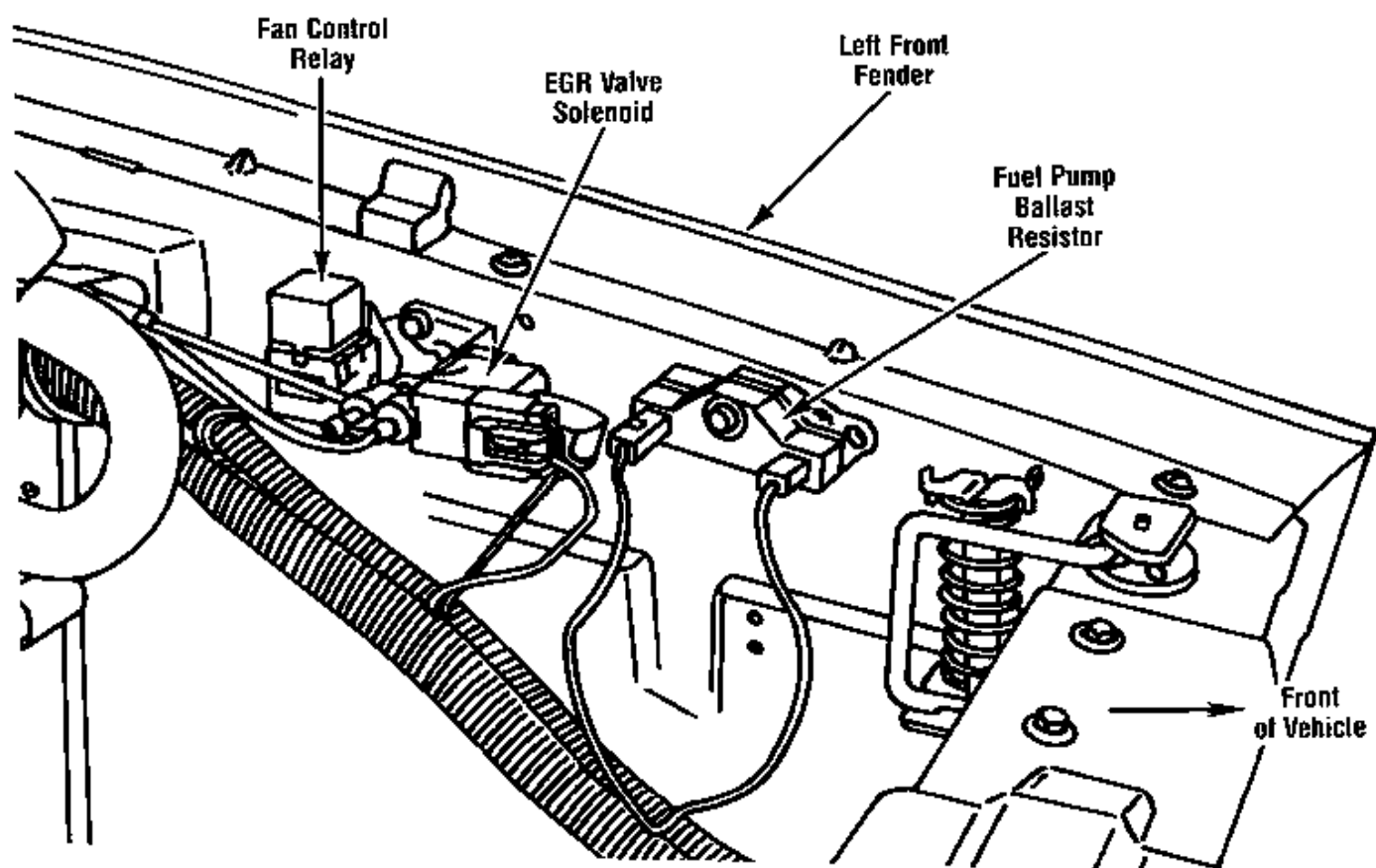


Figure 28 - EGR Solenoid

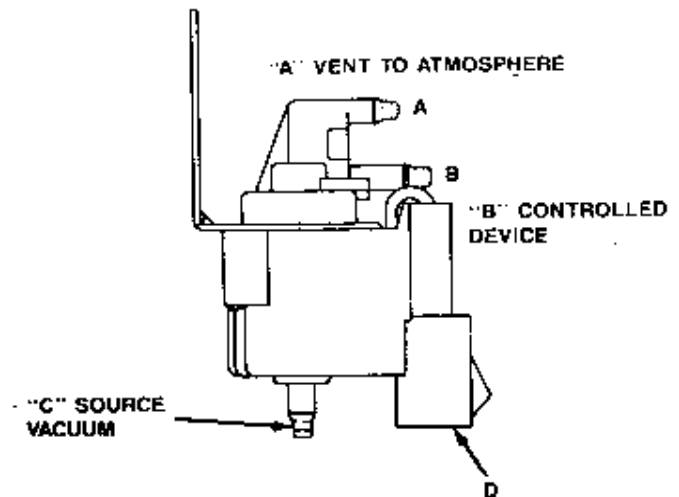
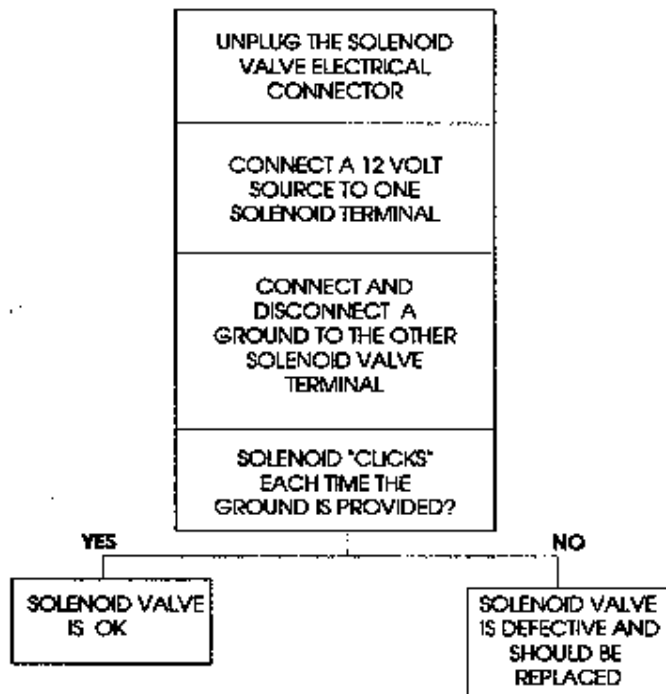
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### COMPONENT TESTING

#### EGR SOLENOID VALVE

##### EGR SOLENOID VALVE TESTING



##### FUNCTION

##### DE-ENERGIZED:

"B" IS CONNECTED TO "C"

##### ENERGIZED:

"A" IS CUT OFF FROM "B" & "C"

"B" IS CONNECTED TO "A"

"C" IS CUT OFF FROM "B" & "A"

**Note:** Using a hand held vacuum pump and the function chart above, you can determine if the solenoid is shifting ports when it becomes energized. A properly working solenoid will work as follows:

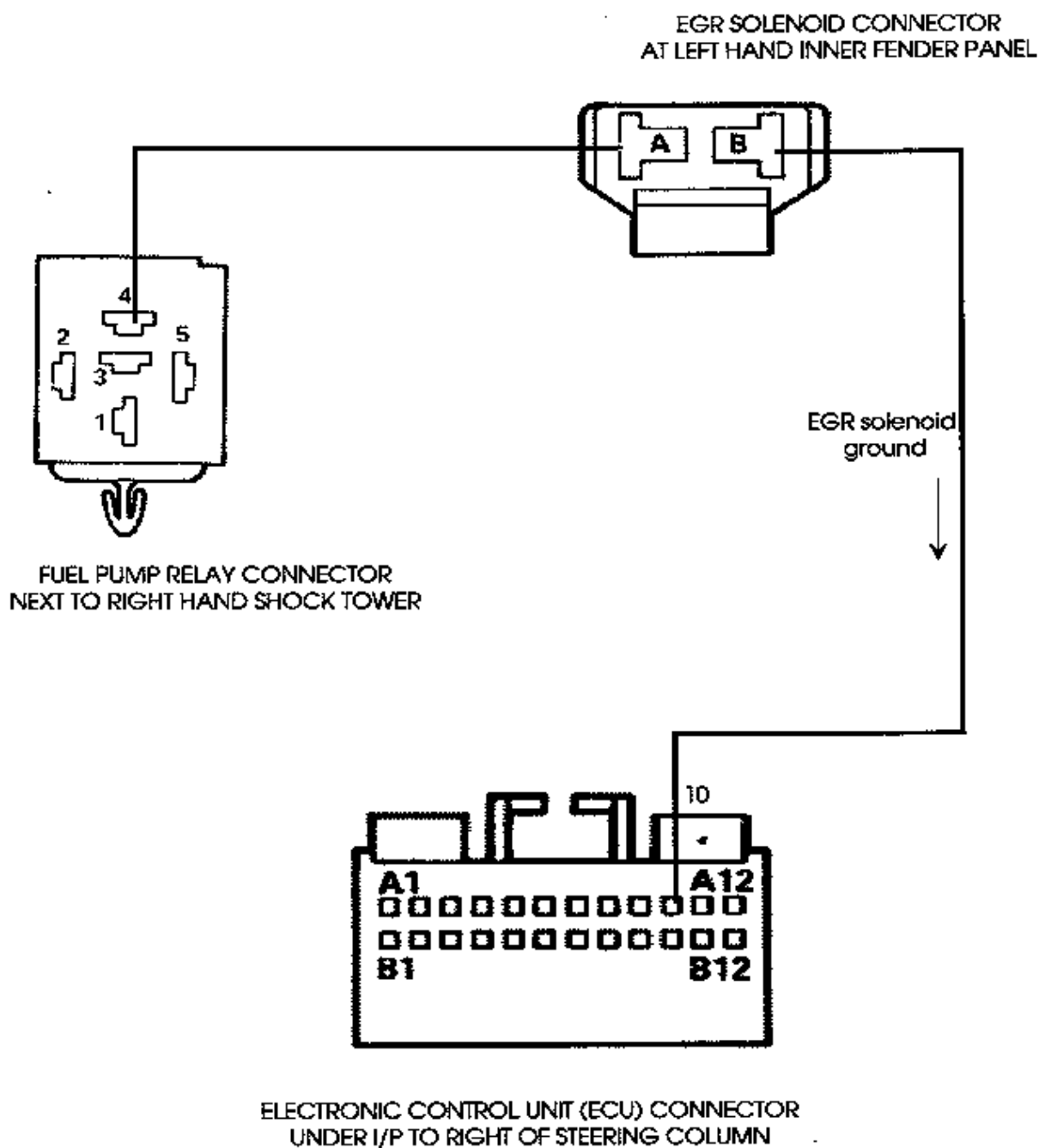
**De-energized Solenoid** - with vacuum applied to port B, vacuum should vent to port C, and with vacuum applied to port A, the solenoid should hold vacuum.

**Energized Solenoid** - with vacuum applied to port B, vacuum should vent to port A, and with vacuum applied to port C, the solenoid should hold vacuum.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### EGR SOLENOID CIRCUIT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### IDLE SPEED STEPPER MOTOR (Fig. 29)

The idle speed stepper motor is mounted on the throttle body and is used by the ECU to control engine idle speed. The throttle body is a cast aluminum housing containing two air flow control valves. One valve, the throttle valve, is mechanically operated by a cable connected to the accelerator pedal. The remaining valve is regulated by a stepper motor controlled by the ECU.

The throttle valve regulates off idle engine speed by controlling the amount of air allowed to enter the intake manifold. The stepper motor controls engine idle speed.

The ECU and idle speed stepper motor control engine idle by regulating the size of an air bypass passage that routes air past the closed throttle plate. The amount of air flowing through the bypass circuit depends on engine operating conditions at idle. When the engine is cold, the ECU increases engine speed by retracting the stepper motor pin, thus allowing more air to enter the intake manifold. To maintain the proper air/fuel mixture, more fuel is also injected into the intake manifold. The increased air/fuel mixture, in turn, raises the engine idle speed. As the engine warms up, the ECU will extend the stepper motor pin into the air passage to reduce the amount of air by-passing the throttle plate.

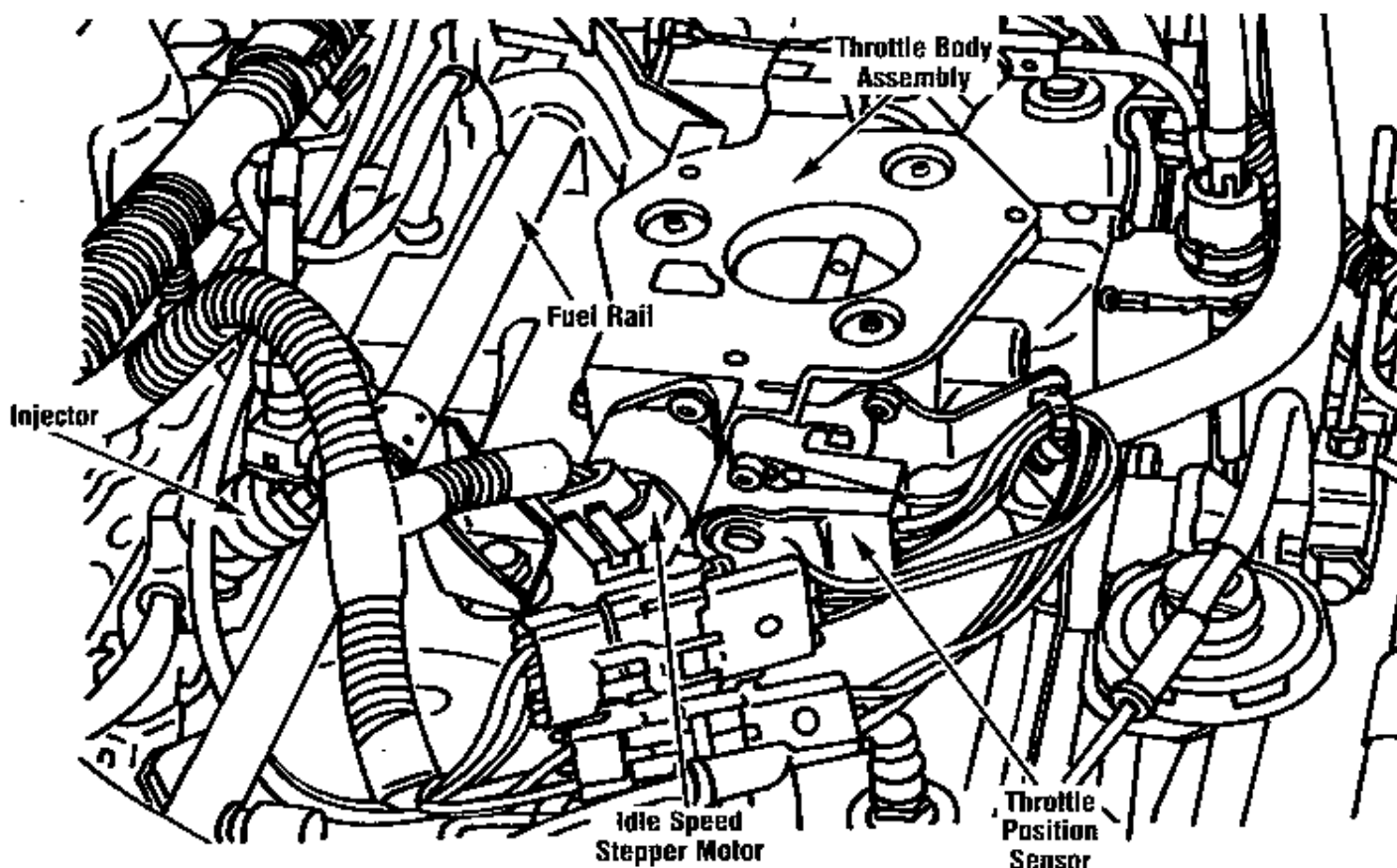


Figure 29 - Idle Speed Stepper Motor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### COMPONENT TESTING

#### IDLE SPEED STEPPER MOTOR (Fig. 30)

The idle speed stepper motor can be tested using the Miller tool # 7558 (formerly Ele. CT-01) exerciser.

**CAUTION:** Proper safety precautions must be taken when testing the idle speed stepper motor.

- Set the parking brake and block the drive wheels.
- route all tester cables away from the cooling fans, drive belts, pulleys, and exhaust components.
- Provide proper ventilation while operating the engine.

1. With the engine OFF, disconnect the idle speed stepper motor wire connector at the throttle body.
2. Plug the exerciser connector into the idle speed stepper motor.
3. Connect the red clip to the battery positive (+) terminal. Connect the black clip to the battery negative (-) terminal.
4. Start the engine.

When the switch is in the HIGH or LOW position, the light on the exerciser will flash indicating that voltage pulses are being sent to the stepper motor.

5. Move the switch to the HIGH position, the engine speed should increase. Move the switch to the LOW position, the engine speed should decrease.
  - a. If the engine speed changes while using the exerciser tool, the idle speed stepper motor is functioning properly. Disconnect the exerciser tool and connect the stepper motor harness wire connector to the stepper motor.

- b. If the engine speed does not change, turn the ignition OFF and proceed to step 6. Do not disconnect the exerciser from the stepper motor.

6. Remove the idle speed stepper motor from the throttle body.

**CAUTION:** When checking the idle speed stepper motor operation with the stepper motor removed from the throttle body, DO NOT EXTEND the pintle more than 6.35mm (0.250 in). If the pintle is extended more than this amount it may separate from the stepper motor. The idle speed stepper motor must be replaced if the pintle separates from the motor.

7. With the ignition OFF, cycle the exerciser tool switch between LOW and HIGH positions and observe the pintle. The pintle should move in and out of the motor.
  - a. If the pintle does not move, replace the idle speed stepper motor. Start the engine and test the replacement stepper motor as outlined in step 5.
  - b. If the pintle operates properly, check the stepper motor bore in the throttle body for blockage and clean as necessary. Re-install the stepper motor.

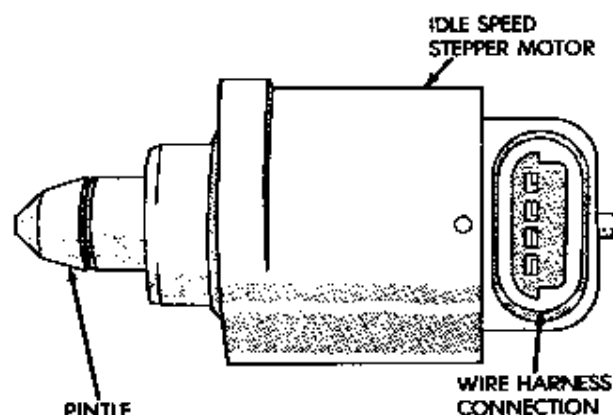
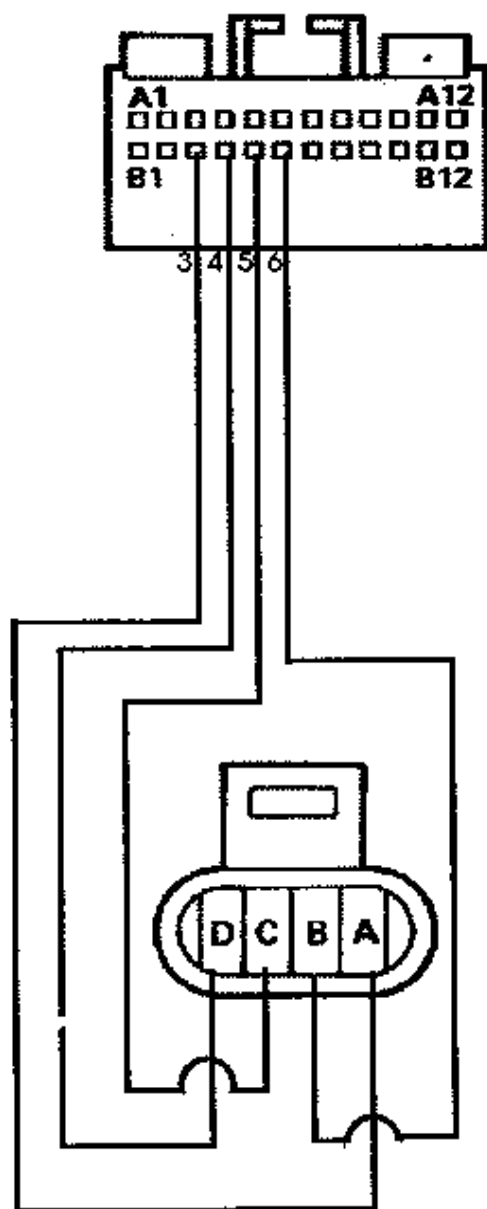


Figure 30 - Idle Speed Stepper Motor

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### IDLE SPEED STEPPER MOTOR CIRCUIT SCHEMATIC





## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### AIR CONDITIONING CLUTCH RELAY (Fig. 31)

The ECU controls the air conditioning compressor clutch through a relay. This allows the ECU to receive an A/C select signal when the driver positions the mode lever in the air conditioning position. The ECU also receives a request signal from the air conditioning temperature control thermostat. The ECU then adjusts idle speed using the idle speed stepper motor. Only then can the ECU activate the air conditioning clutch through the

air conditioning clutch relay. The increased idle speed will compensate for the additional load caused by the A/C compressor.

The system prevents idle speed undershooting and overshooting due to the changing load on the engine caused by the A/C compressor.

**NOTE:** Whenever the A/C clutch is energized, the ECU also energizes the electric cooling fan relay. This occurs regardless of engine coolant temperature.

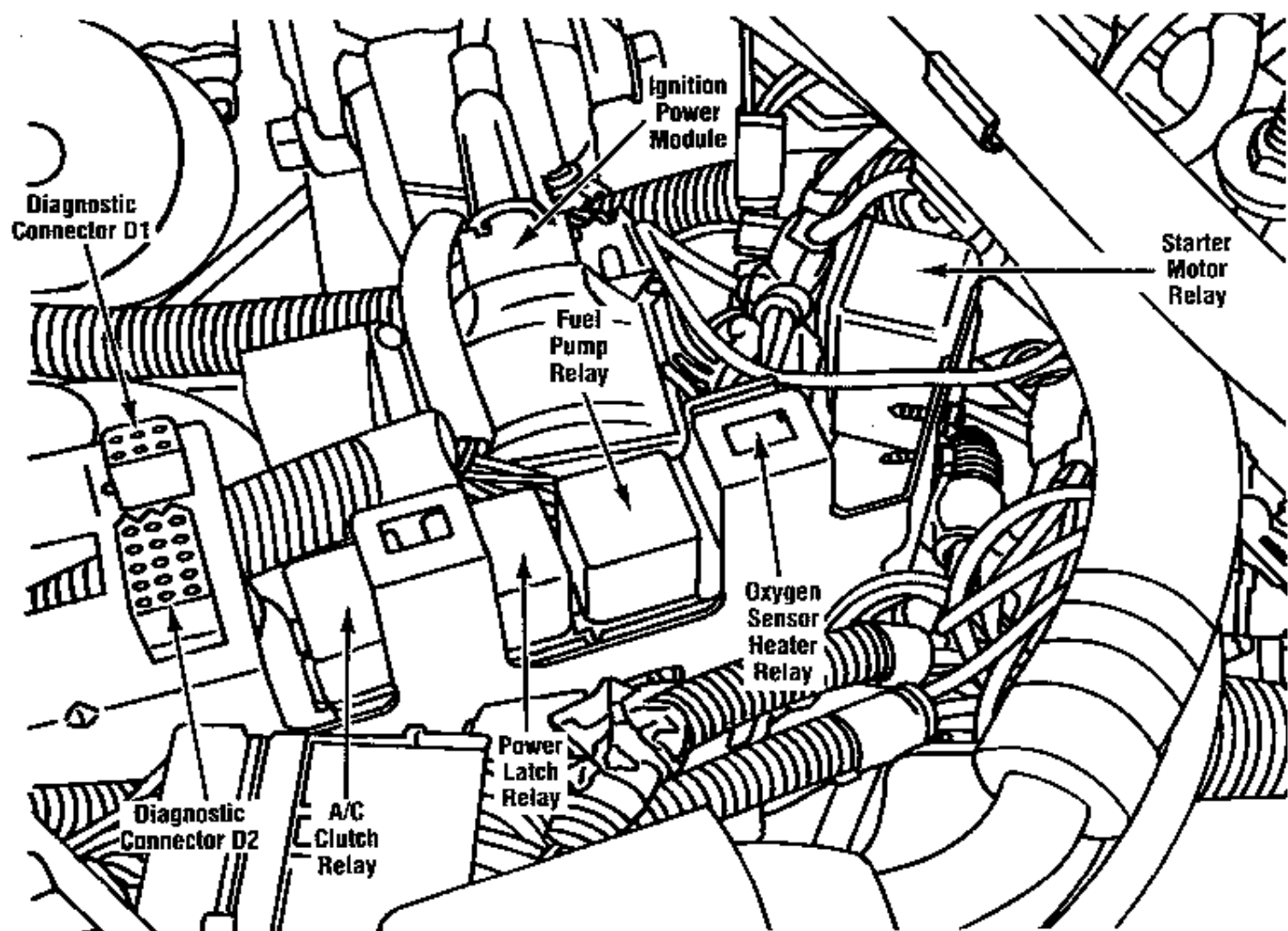
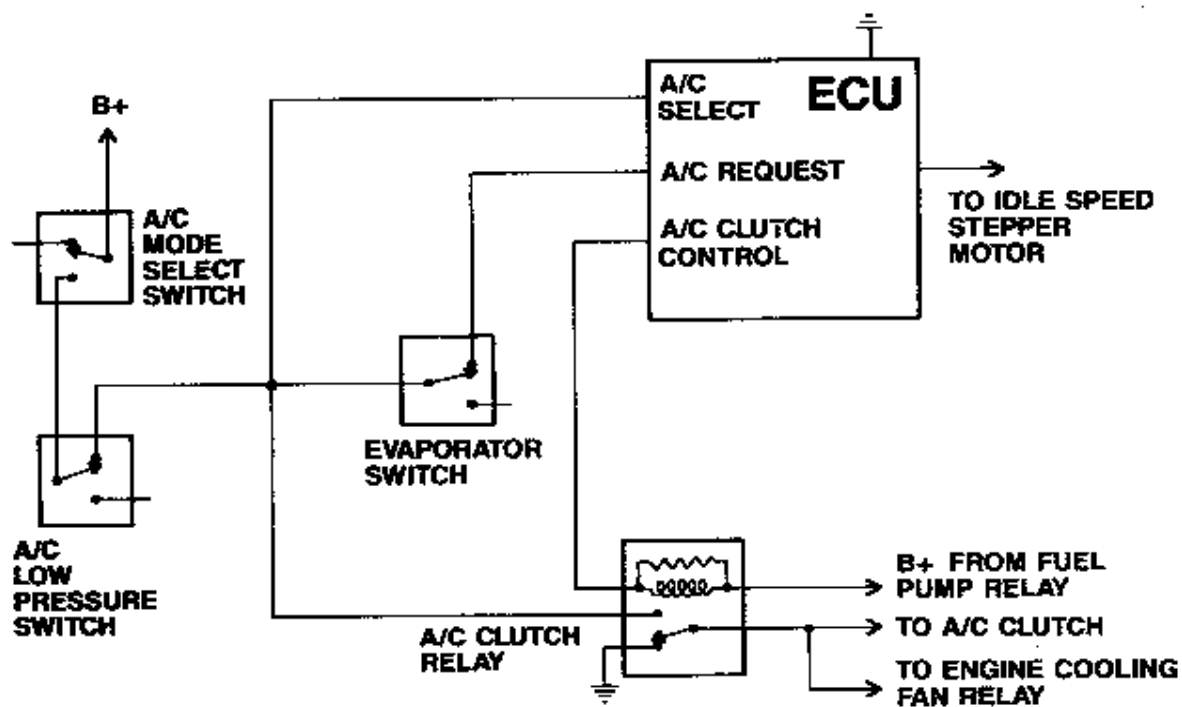


Figure 31 - Air Conditioning Clutch Relay

## 4.0 L MULTI POINT FUEL INJECTION SYSTEM

### ECU OUTPUTS

#### AIR CONDITIONING CLUTCH RELAY OUTPUT SCHEMATIC



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### ELECTRIC COOLING FAN

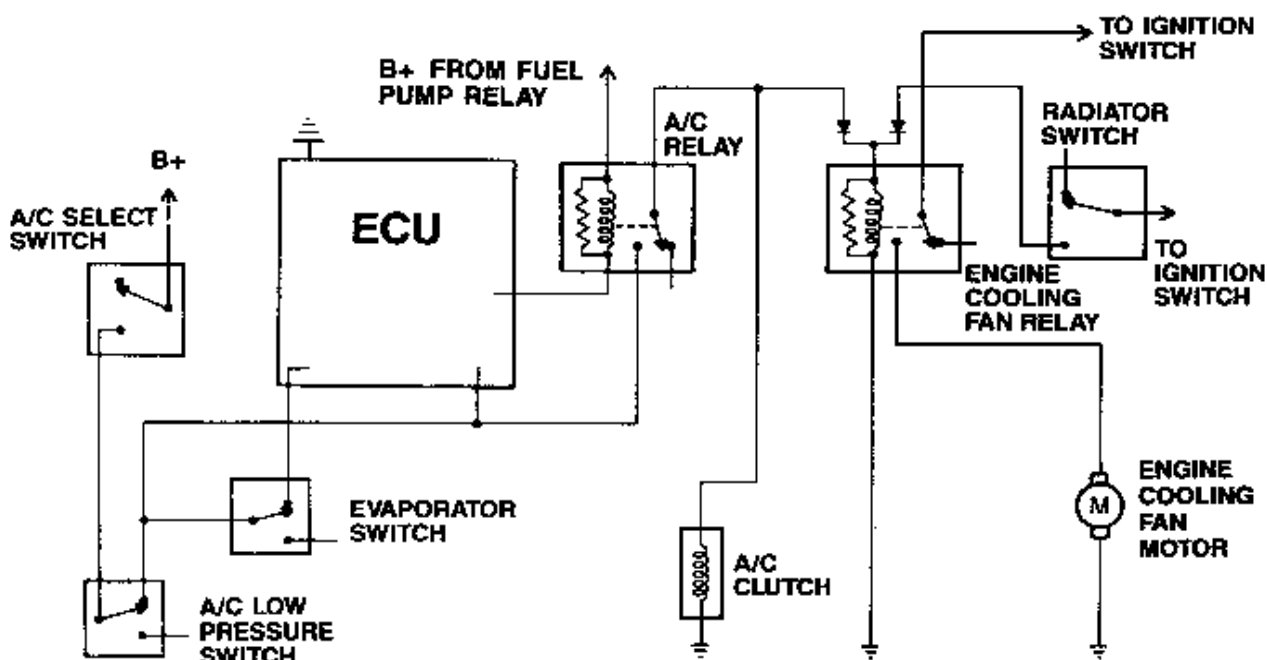
#### ELECTRIC COOLING FAN

An electric cooling fan, in addition to the engine driven fan, is used on vehicles equipped with air conditioning or heavy duty cooling. Normal operation of the fan is controlled by coolant temperature through a radiator mounted temperature switch. It will also operate whenever the A/C clutch is activated regardless of coolant temperature.

When the engine coolant temperature is below approximately 190°F (88°C) - the radiator switch is open and will not allow battery voltage to the cooling fan relay. The fan does not operate because the relay con-

tacts are open. When the coolant temperature reaches approximately 190°F (88°C) the radiator switch closes and allows battery voltage from the ignition switch to reach the relay coil and to ground, thus energizing the relay and allowing battery voltage to the cooling fan motor.

If A/C is selected, regardless of coolant temperature, the ECU provides a ground for the A/C relay coil. With the A/C relay coil energized, the circuit is closed from battery voltage to the A/C clutch and to the engine cooling fan relay. Since the engine cooling fan relay has a permanent ground, the relay is energized and battery voltage is applied to the engine cooling fan motor from the ignition switch.



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### EGR SYSTEM

#### EGR VALVE (Fig. 32)

The EGR valve is mounted on the intake manifold. It is controlled by a EGR transducer and an EGR solenoid. When required, the transducer and the solenoid allow intake manifold vacuum to pull the EGR valve open. Exhaust back pressure also helps to open the EGR valve.

#### EGR TRANSDUCER (Fig. 32 & 32A)

The EGR transducer is mounted in line above the EGR valve. It controls the operation of the EGR valve.

The EGR solenoid, when energized by the ECU, restricts vacuum to the EGR transducer. When the EGR solenoid is not energized, it allows vacuum to the EGR transducer.

The EGR transducer consists of a diaphragm and three ports.

- one port receives an exhaust back pressure signal from a vent in the EGR valve housing.

- one port receives a vacuum signal from the intake manifold.

- one port routes controlled vacuum out to the EGR valve diaphragm.

The transducer is controlled by exhaust back pressure. When back pressure is high enough, it will close a bleed in the transducer allowing vacuum to actuate the EGR valve.

When the engine is running, vacuum is applied to the solenoid from a vacuum port in the throttle body. If the ECU has energized the EGR solenoid, vacuum will not flow through the solenoid or the transducer. If the solenoid has not been energized by the ECU, vacuum will flow through the solenoid and the transducer. If the exhaust back pressure is high enough to close the vacuum bleed in the transducer, vacuum will flow to the EGR valve. If the back pressure is not high enough the vacuum will bleed off. When the vacuum reaches the EGR valve, the diaphragm is pulled up causing the EGR valve pintle to move off its seat allowing exhaust gases to enter the intake manifold and finally the combustion chambers.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### EGR SYSTEM

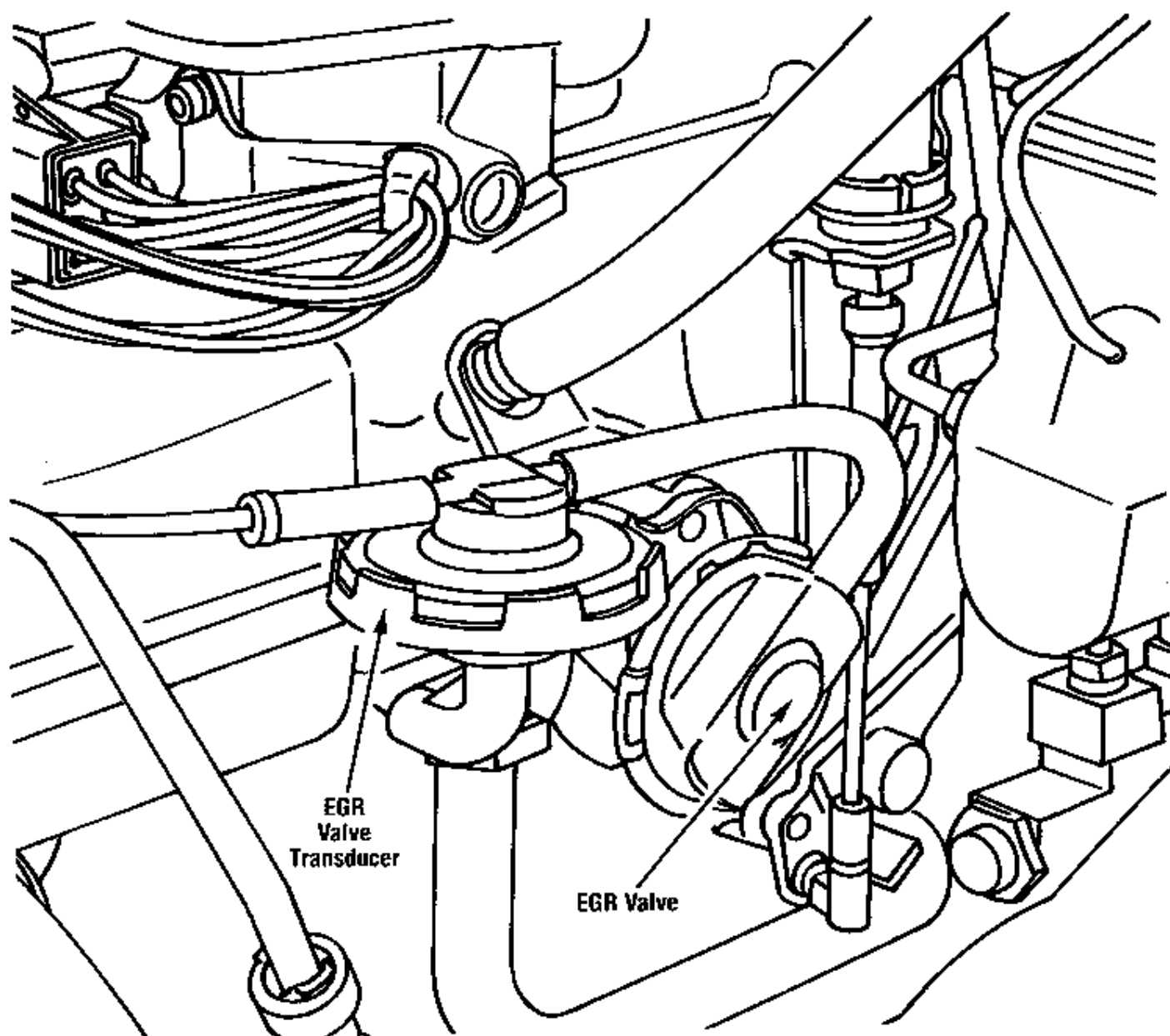
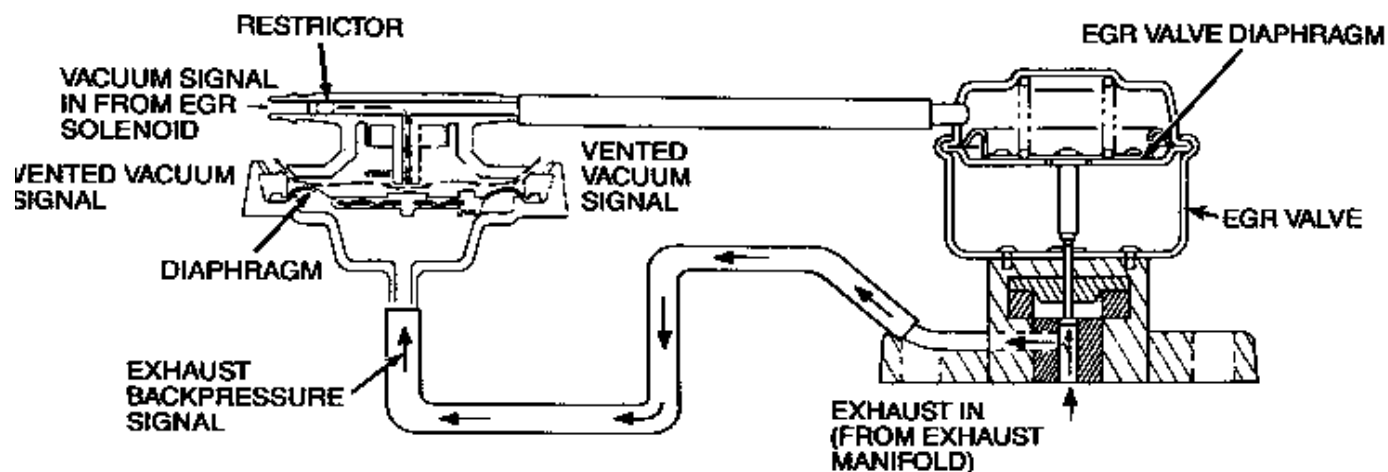


Figure 32 - EGR Valve/Transducer

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### EGR SYSTEM

#### LOW BACK PRESSURE



#### HIGH BACK PRESSURE

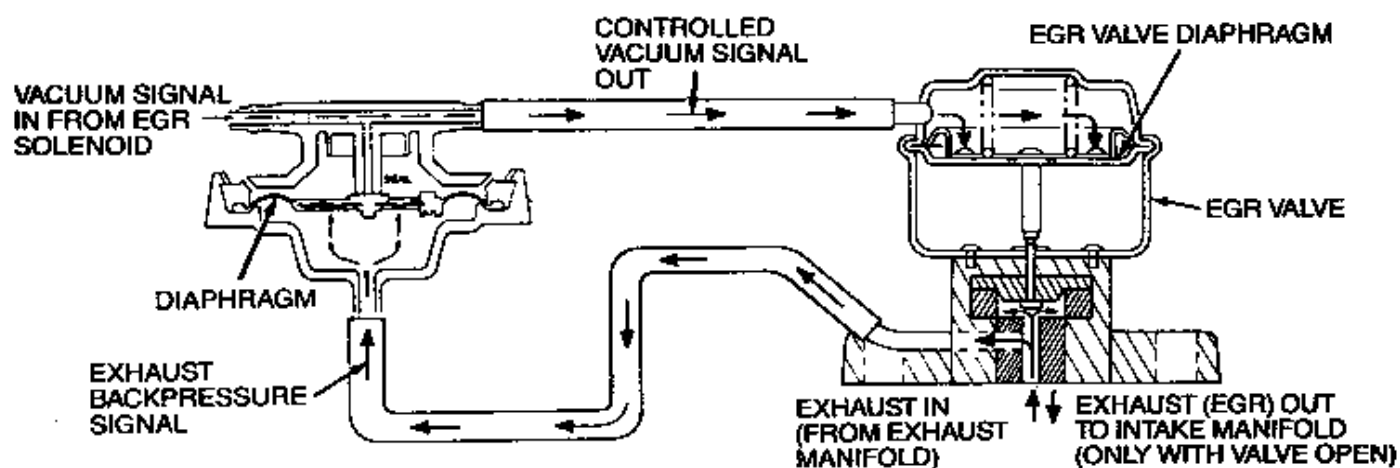


Figure 32A - EGR Transducer Operation

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### EVAPORATIVE EMISSION SYSTEM

#### CHARCOAL CANISTER (Fig. 33)

The evaporative Emission Control System prevents the release of unburned hydrocarbons (from liquid gasoline or gasoline vapor) into the atmosphere. The 4.0 liter engine utilizes a venturi in the air cleaner assembly as a purge line vacuum source. The effect of the venturi increases the speed of the intake air flowing by the purge inlet slots. As intake air is accelerated past the purge inlet slots in

the inner walls of the venturi, a vacuum (low pressure area) is created between the inner and outer walls of the air cleaner assembly. This vacuum is applied through the canister purge lines and purges the vapor storage canister into the fresh air stream running to the throttle body. As engine air flow increases, so does the vacuum applied to the vapor storage canister. An external nipple on the outer wall of the air cleaner assembly provides a connection for the canister purge line.

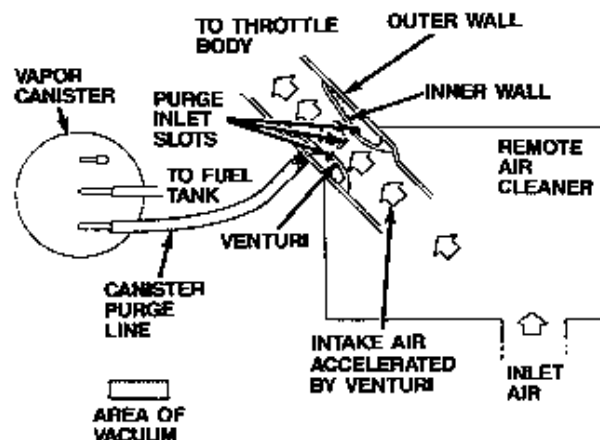
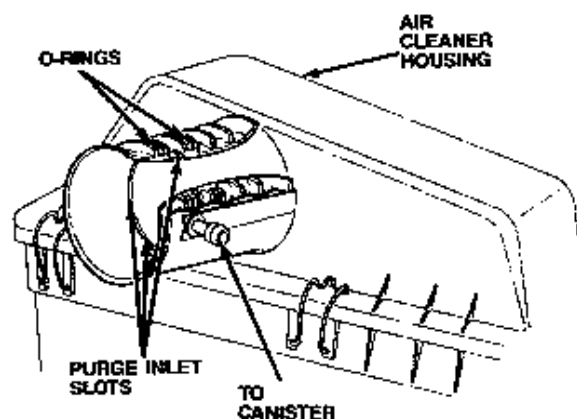


Figure 33 - Evaporative Emission System

# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### INTRODUCTION

In this section of the book the separate components are combined into a functioning system. The inputs the ECU receive and how it reacts with the outputs are explained in the following modes of operation:

- Key ON
- Crank
- Warm-up
- Idle Mode - Operating Temperature
- Cruise Mode - Operating Temperature
- Deceleration
- Wide Open Throttle
- Key OFF

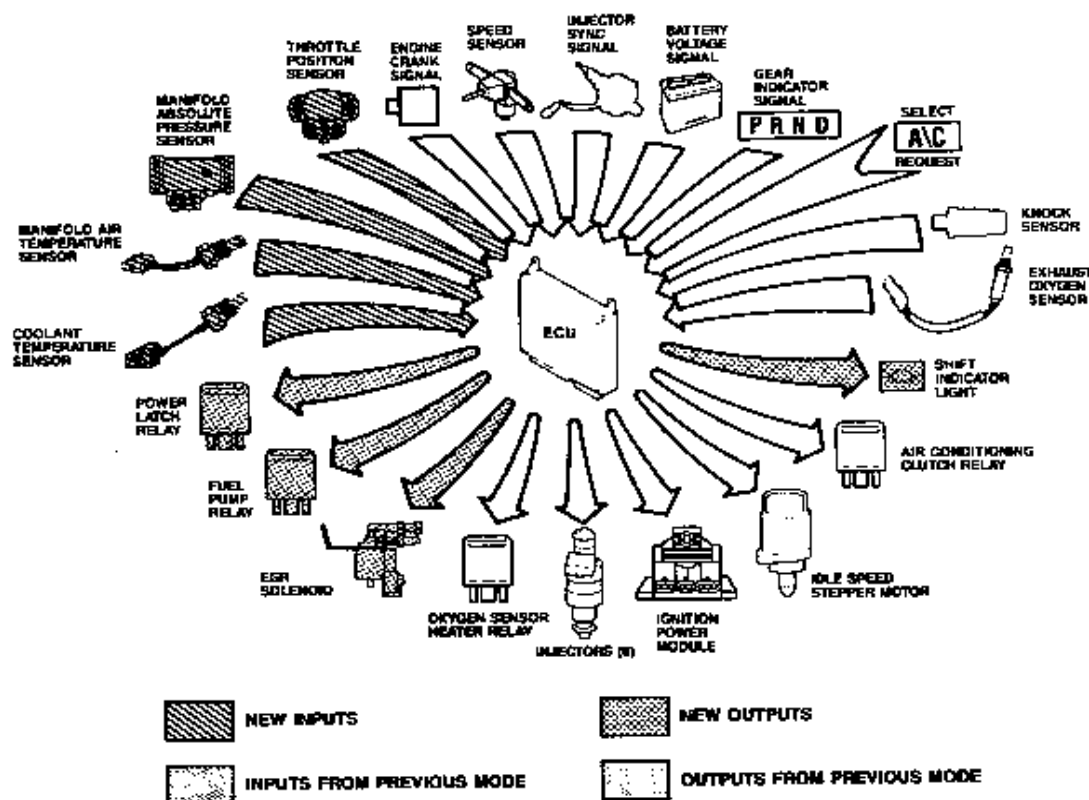
### KEY "ON" MODE

When the ECU is turned to the ON position the ECU receives information from the following inputs:

- Coolant temperature sensor
- Air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor

Voltage is supplied to the fuel pump relay and the ECU completes the pump relay ground circuit for 1 to 3 seconds to prime the fuel line. The system power latch relay is energized for 1 to 3 seconds. The ECU stores the MAP sensor barometric pressure input in anticipation of a start up. The heating element in the oxygen sensor is activated by the ECU through the normally closed heater relay.

The EGR solenoid is energized by the ECU which restricts operation. On manual transmission equipped vehicles, the shift indicator light is illuminated to check the lamp operation.





# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### CRANK MODE OPEN LOOP

During engine cranking, the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Starter relay
- Engine speed sensor signal
- Sync signal generator
- Battery voltage

The engine crank input from the starter relay provides a signal to the ECU to energize the fuel pump relay and to begin the start sequence. The ECU determines the correct cranking speed (approximately 300 rpm) by counting the flywheel teeth passing the speed sensor. With the proper cranking input the ECU will synchronize the fuel injector opening and the spark plug firing. The ECU determines the correct injector

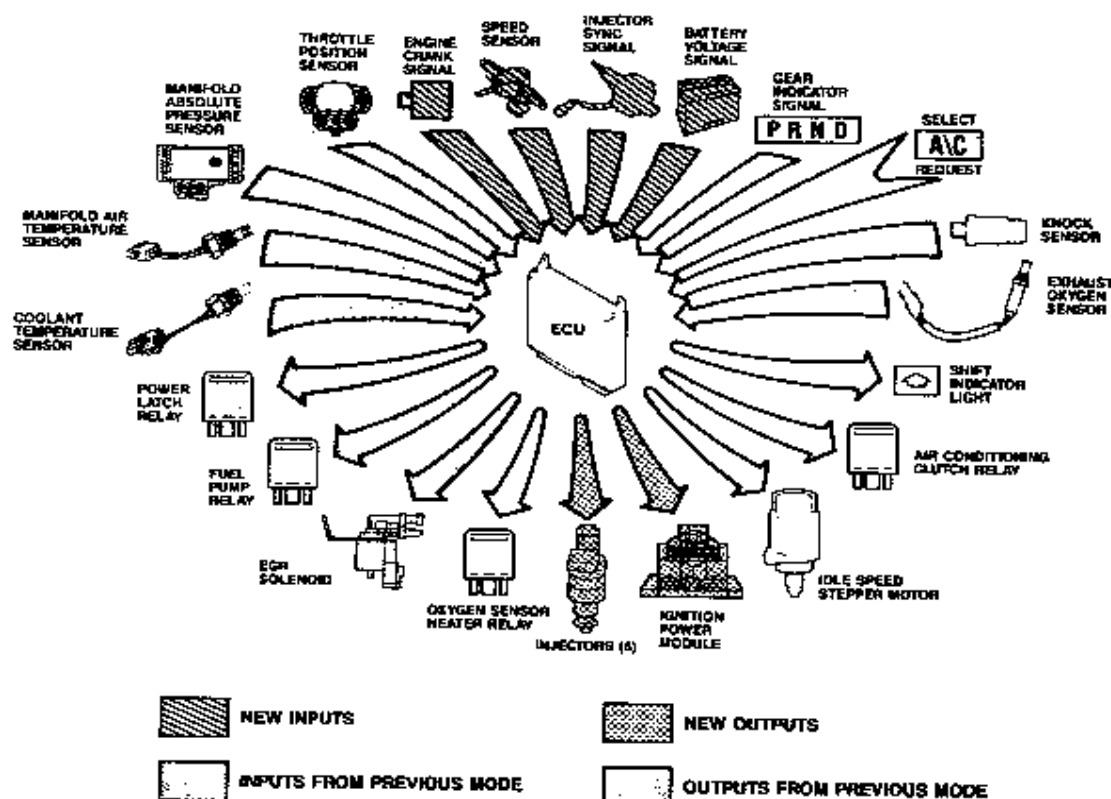
pulse width and opens the injectors in the proper order by supplying a battery voltage signal.

The sync signal input from the distributor provides the signal needed by the ECU to locate number one or number six piston. When the number one or number six piston is on its exhaust stroke, and the ECU receives all other crank mode inputs, the ECU energizes the injector for that piston. The ECU uses either piston one or piston six as the number one in the firing order.

If the ECU does not receive a sync signal input, it will randomly select an injector as number one in the firing order and use it to sequence the fuel injectors. The engine will probably start, but performance will be noticeably poor.

**NOTE:** If the ECU detects a wide open throttle condition, the ECU assumes that a flooding condition exists. It will open all circuits to the injectors and will not resume fuel injector opening until engine speed reaches approximately 400 rpm.

The EGR solenoid is energized by the ECU to restrict operation.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### WARM-UP MODE OPEN LOOP

During warm up the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Sync signal generator
- Battery voltage
- Gear indicator signal (automatic only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Knock sensor
- Oxygen sensor

Battery voltage is supplied to the appropriate injector - with the correct sequence and pulse width - by the ECU. The proper pulse width is based on the following ECU inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Oxygen sensor

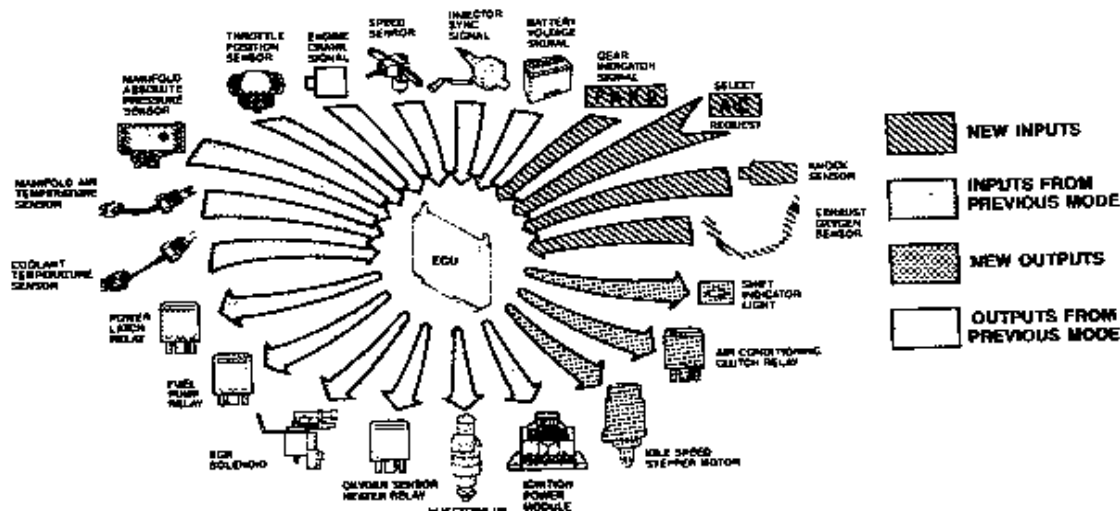
The sync input is monitored by the ECU to keep the injector firing sequence in proper order. The oxygen

sensor input is monitored by the ECU. The ECU determines the proper idle speed based on coolant temperature sensor and sends a control signal to the idle speed stepper motor. The throttle position sensor provides the ECU with information on the throttle position. This information is used in conjunction with the other sensors to determine the proper injector pulse width and spark advance.

The ECU operates the air conditioning clutch through the clutch relay if air conditioning has been selected by the driver and requested by the A/C thermostat. The ECU determines and controls the proper ignition timing. On vehicles equipped with manual transmissions, the shift indicator light is operated by the ECU based on engine speed and load. This indicates to the driver that a gear change is suggested. If the suggested shift is not performed, the ECU will turn the light out after 3 to 5 seconds.

The EGR solenoid is energized by the ECU to restrict EGR operation. Based on engine coolant temperature and a timer, the ECU determines the duration of the warm up period. When the ECU determines that the engine has reached operating temperature, input from the exhaust oxygen sensor is checked and the system goes into closed loop operation. This signifies the end of the Warm-up mode.

**NOTE:** If the ECU does not receive an input from the coolant temperature sensor, it will simulate the sensor input by defaulting to the input from the air temperature sensor and add 1/2 degree C. every 85 engine revolutions.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### IDLE MODE CLOSED LOOP

At idle speed, the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Sync signal generator
- Battery voltage
- Gear indicator signal (automatic only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Knock sensor
- Oxygen sensor

The ECU determines the required idle speed and sends a control signal to the idle speed stepper motor. The ECU operates the air conditioning clutch relay through the clutch relay if air conditioning has been

selected by the driver and requested by the A/C thermostat.

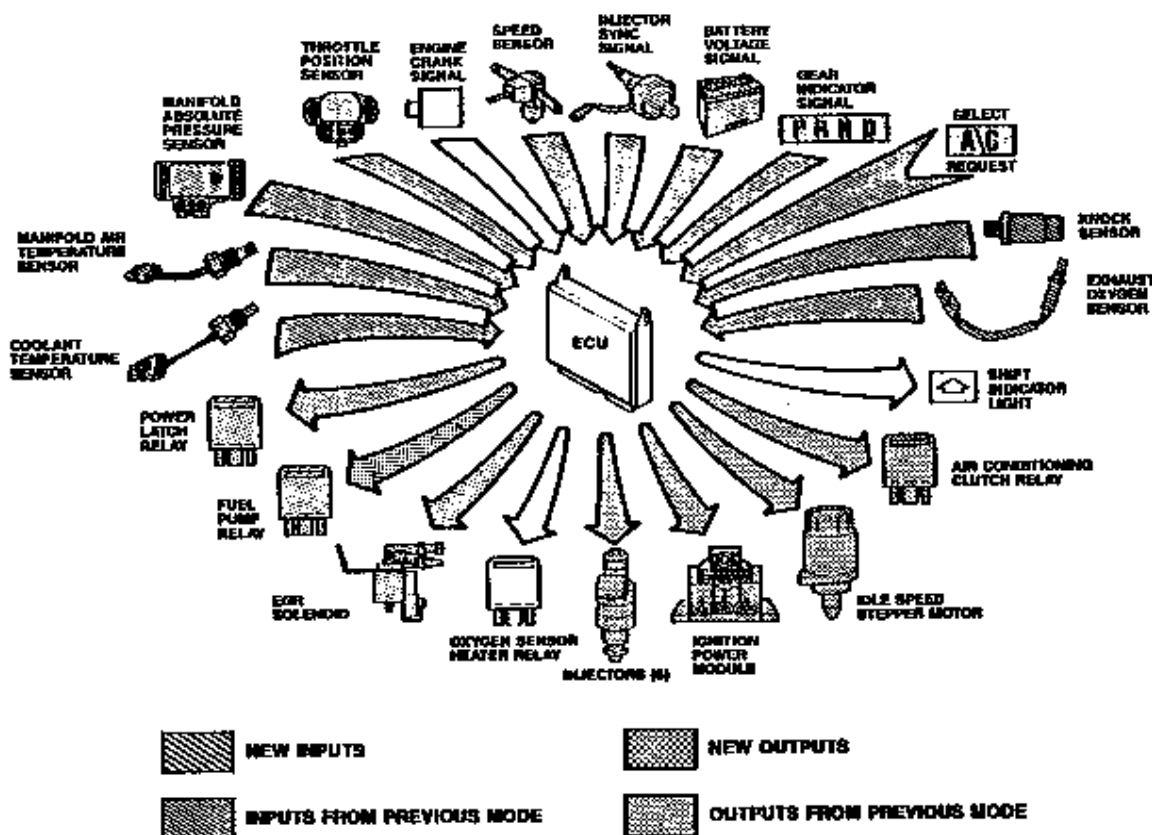
The ECU determines and controls the proper Ignition timing. If a knock is detected in one or more cylinders, the ECU retards Ignition timing. After 10 to 15 seconds, ignition timing will progressively return to its prior value once the knock condition has been eliminated.

The oxygen sensor input information is used by the ECU to determine the proper air/fuel ratio.

The Sync signal is monitored by the ECU to keep injector operation in the proper sequence.

Voltage is supplied by the ECU to the appropriate injector. The ECU uses this voltage signal to control the pulse width ("on" time) of each injector.

The EGR solenoid is energized by the ECU. This action disables the EGR system by totally restricting vacuum to the EGR valve.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### CRUISE MODE CLOSED LOOP

At cruising speed, the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Sync signal generator
- Battery voltage
- Gear indicator signal (automatic only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Knock sensor
- Oxygen sensor

The oxygen sensor input information is used by the ECU to determine the proper air/fuel ratio. Voltage is supplied by the ECU to the appropriate injector. The ECU uses this voltage signal to control the pulse width ("on" time) of each injector. The throttle position sensor provides the ECU with information on the throttle position. This sensor will tell the ECU if a closed

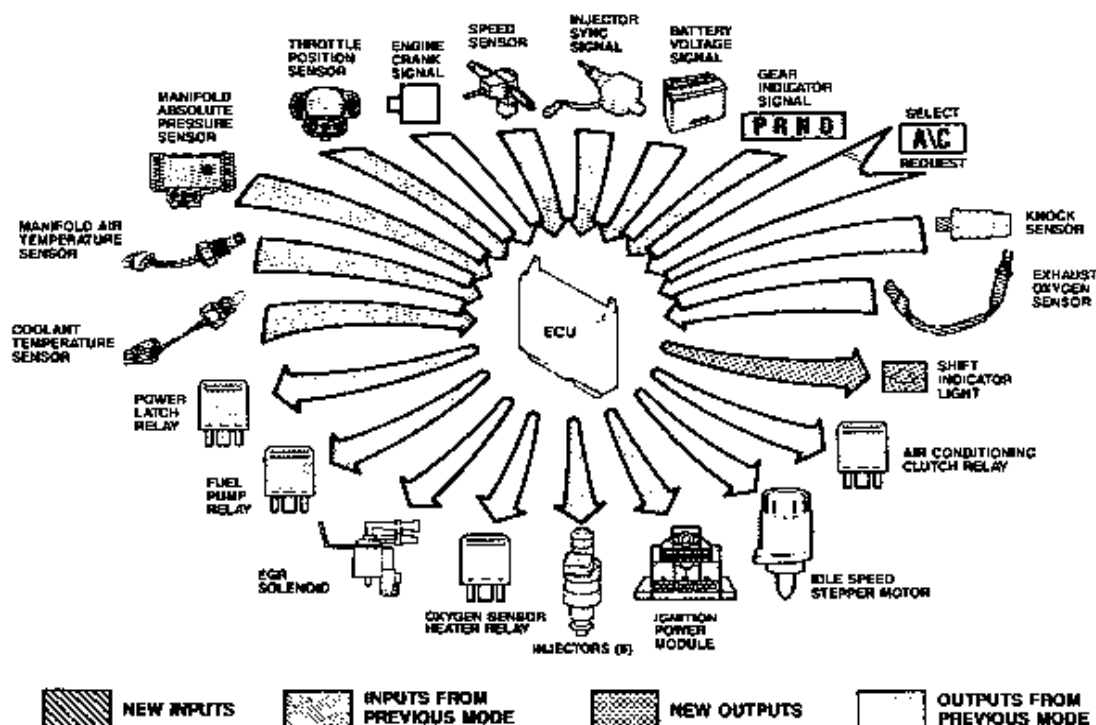
throttle, wide open throttle, or any position in between is present. The ECU uses this information in conjunction with other sensors to determine the proper injector pulse width, spark advance and idle speed stepper motor position.

The Sync signal is monitored by the ECU to keep injector operation in the proper sequence. The ECU determines and controls the proper ignition timing. If a knock is detected in one or more cylinders, the ECU retards ignition timing. After 10 to 15 seconds, ignition timing will progressively return to its prior value once the knock condition has been eliminated.

The ECU breaks the ground for the EGR solenoid allowing vacuum to pass, and exhaust gases are circulated through the combustion chambers.

The ECU operates the air conditioning clutch through the clutch relay if air conditioning has been selected by the driver and requested by the A/C thermostat.

On vehicles with a manual transmission, the shift indicator light is operated by the ECU based on engine speed and load. This indicates to the driver that a gear change is suggested for maximum fuel economy.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### DECELERATION MODE

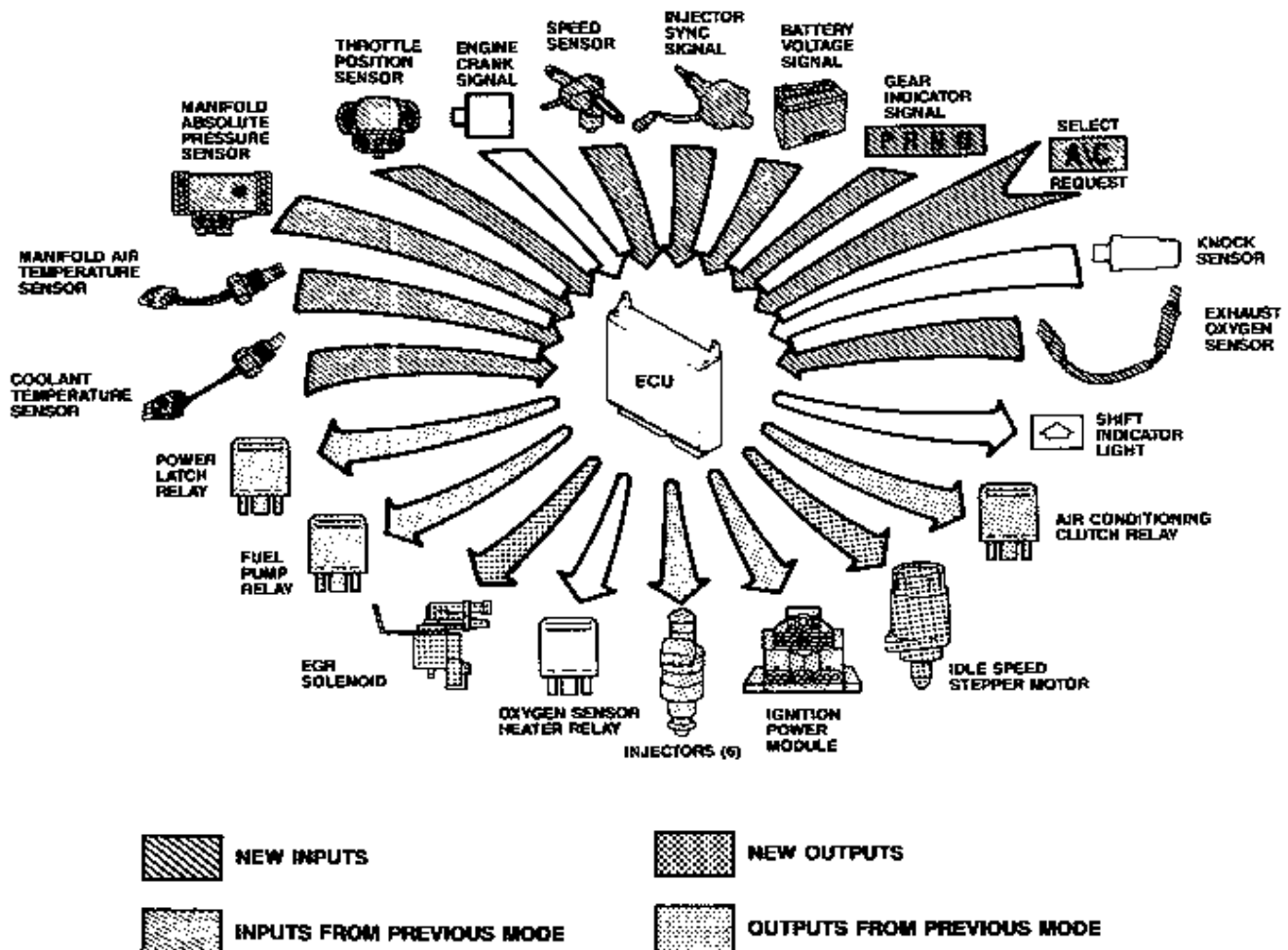
#### CLOSED LOOP

During deceleration, the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Sync signal generator
- Battery voltage
- Gear indicator signal (automatic only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Oxygen sensor

If the proper rpm and closed throttle conditions are met (hard decel), the ECU will enter a fuel cut-off strategy. The ECU will not supply power to the injectors. If a hard decel condition does not exist, the ECU determines the proper injection pulse width and energizes each injector.

The ECU determines the required idle speed and sends a signal to the idle speed stepper motor. The ECU determines proper ignition timing. The ECU provides a ground circuit for the EGR solenoid. The energized solenoid interrupts the vacuum signal and EGR functions stop.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### WIDE OPEN THROTTLE MODE OPEN LOOP

During Wide Open Throttle, the ECU receives information from the following inputs:

- Coolant temperature sensor
- Manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor
- Engine speed sensor signal
- Sync signal generator
- Battery voltage
- Knock sensor

The ECU controls the length of injection by controlling each injector's power circuit.

The Sync Input is monitored by the ECU to keep injector operation in the proper sequence.

When the ECU determines that a wide open throttle condition exists, it completes the ground to the EGR solenoid. The relay interrupts the vacuum signal and this function stops.

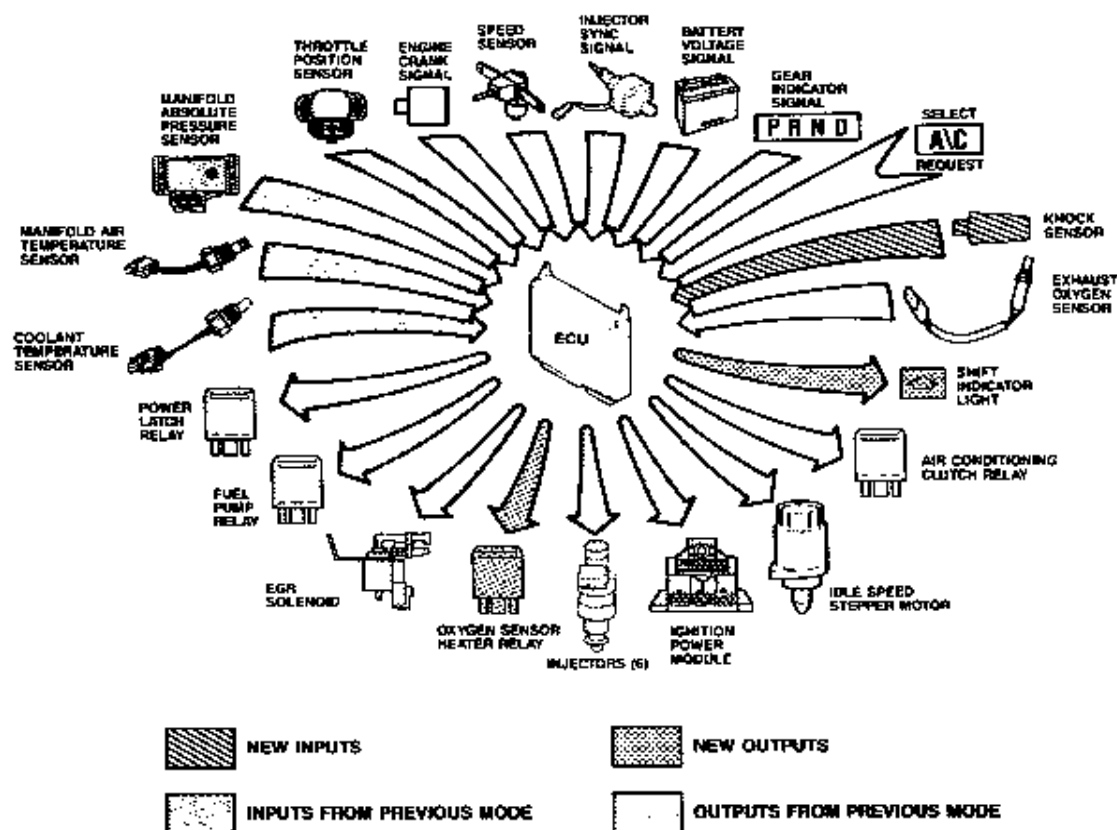
The ECU determines proper ignition timing. If a knock condition is detected, the ECU retards ignition timing and progressively returns the timing to normal once the knock condition has been eliminated.

The ECU ignores the oxygen sensor input signal and provides a predetermined amount of additional fuel.

The ECU energizes the exhaust oxygen sensor heater relay, opens the relay's contacts, and terminates power to the sensor's heating element.

The air conditioning clutch relay is disengaged by the ECU via the clutch relay for approximately 15 seconds.

On vehicles equipped with manual transmissions, the shift indicator light is operated by the ECU to indicate that a gear change is suggested.



# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## MODES OF OPERATION

### KEY OFF MODE

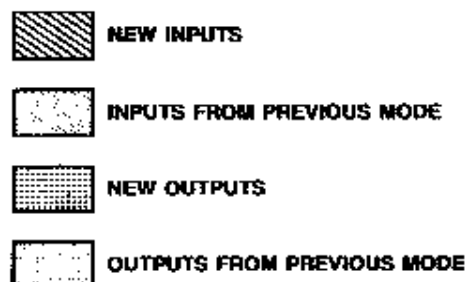
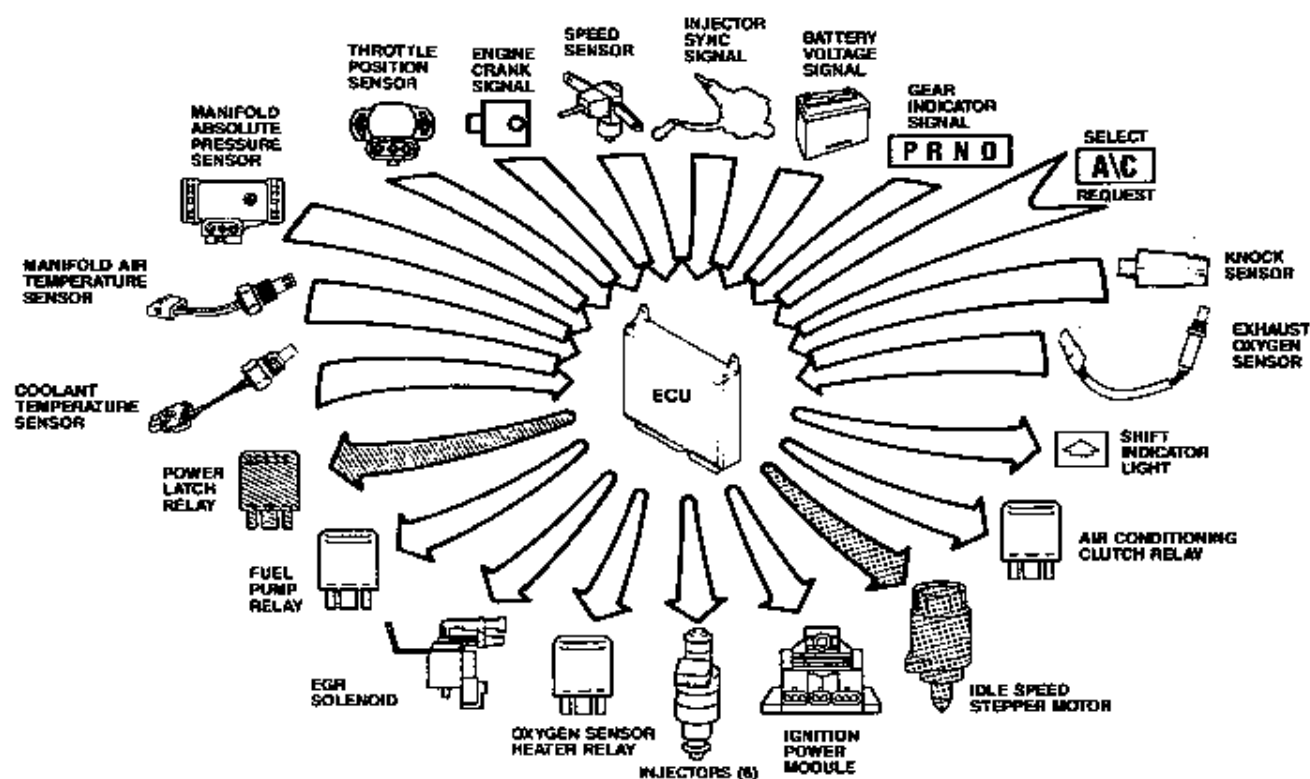
When the Key is turned to the OFF position, the ECU stops supplying power to the injectors.

Ignition system power is shut OFF.

The fuel pump relay is de-energized and the fuel pump stops.

The ECU positions the idle speed stepper motor in anticipation of the next start up.

The ECU de-energizes the system power latch relay.



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

#### ECU ON BOARD DIAGNOSTICS

Features have been provided in the ECU to test and monitor some of its various inputs and outputs. Testing is performed at different times during ECU operation.

**POWER UP:** During "power up" (Key ON, Engine not running), the ECU checks for faults in the ignition module (MPA) circuit, fuel injector(s) circuits, EGR solenoid circuit, A/C relay circuit, Exhaust Oxygen Sensor heater circuit B+ latch relay circuit, and the shift lamp circuit. It is possible, as a consequence of these tests, that the DRB II diagnostic tester may even determine whether or not the ECU is defective. Faults reported via the DRB II diagnostic tester, resulting from these

ECU "power up" tests, are generally permanent faults and are unlikely to be intermittent.

Faults generated during the "power up" tests will remain stored until the ECU is powered down (key off).

**RUNNING:** While the engine is running, the ECU continually tests various sensors to determine whether or not they are performing within a proper operating range. The ECU determines the type of fault that occurred and how long ago (number of engine starts) is occurred. The following sensors are tested by the ECU when the engine is running:

SENSOR	TEST INTENT
Manifold Air Temperature	Check that sensor voltage is between upper and lower limits (open or short circuit conditions)
Engine Coolant Temperature	Same conditions as Manifold Air Temperature
Throttle Position Sensor	Checks that throttle position lies between acceptable limits (open or short circuit conditions)
Manifold Absolute Pressure (MAP)	Checks that sensor voltage is between upper and lower limits (open or short circuit conditions)



## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

While the engine is running, the ECU also monitors transitions between the RICH and LEAN air/fuel state during CLOSED LOOP operation. If a failure is sensed (lack of transition), the system is forced into OPEN LOOP and a fault is stored indicating whether the sensor failed RICH or LEAN.

Faults stored in Keep Alive Memory (KAM) from tests performed while the engine is running will remain stored after the ECU is powered down (Key OFF). A fault must be present for a period greater than two seconds to be stored.

KAM faults will remain stored while the problem is present or until a pre-programmed number of engine starts have occurred since the ECU has recognized the problem. Once a fault has been stored, the ECU will keep count of the number of times that the engine has been started and the number of system attempts to enter CLOSED LOOP. If the count reaches a preset limit and the fault has not recurred, it is erased from the ECU.

Note that faults reported as a result of ECU testing while the engine is running, are in many cases, intermittent, and as such, may or may not be present during the normal DRB II vehicle tests. Further, in all cases where a fault is reported through the ECU tests, a complete DRB II vehicle test should be performed to determine whether the fault is present while diagnostics are being performed. If the same fault is not reported during a DRB II diagnostic test, an intermittent fault can be assumed.

It must be emphasized that an intermittent fault may or may not be the cause of a symptom or performance complaint as reported by an owner. These faults should only

give direction as to which circuit or circuits to investigate (typically, by inspecting and/or "wiggling" the wiring harness and connectors in an attempt to isolate broken wires, frayed insulation, or defective contacts), if the DRB II vehicle test do not report any faults.

### ENGINE STATE DISPLAY FUNCTION

The Engine State Display function enables the technician to view what the Electronic Control Unit (ECU) actually is monitoring at the input and output circuits. The State Display provides the information converted to a value scale familiar to the technician.

The State Display function is selected from the MAIN MENU by pressing the corresponding number next to the State Display. Data can be viewed at any time with the key ON (even if the engine is not running). Pressing the (↓) yes key will cause the tester to move down through the following information. The (↑) no key will move up through the list of data. Continuing beyond the last item (by pressing successive (↓) yes's) or backing up (by pressing successive (↑) no's) will result in looping through the display items.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

#### STATE DISPLAY

Vehicle Program and Calibration Code  
Battery  
Engine Coolant Temperature (H2O)  
Manifold Air Temperature  
Throttle Position Sensor Status (TPS)  
A/C SEL PRE\* CL CO (\* A/C Request on later models)  
EGR+ LATCH+ FUEL+  
Barometric Pressure  
Vacuum (MAP)  
RPM  
Exhaust Oxygen Sensor  
Ignition Advance  
Knock information  
Sync Signal  
Injector Pulse Width (MS)  
AlfaCL  
ADGAIN - Adaptive Gain\*\*  
ADZERO - Adaptive Offset\*\*  
Closed Throttle Average (CTAV)  
KAM - O2  
KAM - MAP  
KAM - TPS  
KAM - AIR TEMPERATURE  
KAM - COOLANT TEMPERATURE  
Warranty

*\*\* a value used by the ECU to adjust to driving conditions, or base engine conditions to get to Stoichiometry faster.*

#### KAM (Keep Alive Memory)

Faults are displayed in the format of: Device xx yy where Device is a designation of the sensor monitored, xx is a one or two digit number indicating the value stored for "low" value failures, and yy is a one or two digit number indicating value stored for "high" value failures. If the ECU detects a low or high value fault in one of the sensors monitored, the respective KAM sensor value will be set to 15. If the engine is started and CLOSED LOOP operation is attempted and the fault is no longer present, the respective KAM value will be decreased by one. If the fault is still present, the value will remain at 15. Values of zero are an indication that no

"low" or "high" value fault has been detected for a specific test by the ECU. Values less than 15 and greater than 0 are an indication that the ECU has detected a fault at some time, but that fault is not present during this start cycle.

KAMS Fault Displayed are:  
Exhaust Oxygen (O2) Sensor  
MAP Sensor  
Throttle Position Sensor  
Manifold Air Temperature Sensor  
Engine Coolant Temperature Sensor

#### MIN/CUR/MAX

This display option allows the technician to observe the operation of up to six different engine sensor values over time. Information is displayed as three separate two-digit numeric values. The first value displays the minimum reading. The second value displays the current reading. The last value displays the maximum reading. The six components that can be monitored are:

- MAP Sensor
- Exhaust Oxygen Sensor
- Throttle Position Sensor
- Engine Coolant Temperature Sensor
- Manifold Air Temperature Sensor
- CATV (Average learned closed throttle value)

The Min/Cur/Max display can be used to observe the effects of intermittent faults introduced either through a road test or through a "wiggle test". Typical values for sensors range from 2 to 252. Values less than 2 or greater than 252 usually indicate that a sensor is shorted or disconnected. In using the Min/Cur/- Max display, one should look for sudden changes in either the minimum or maximum values. Sudden changes are usually an indication of intermittent faults.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

#### ECU CHECKOUT PROCEDURE

The condition of the ECU is determined by the elimination of other potentially defective components or wiring faults in a specific circuit. Even though the ECU is determined to be faulty by process of elimination, it should not be replaced until it has been retested after some basic screening procedures have been performed.

Most electrical/electronic devices are incorrectly diagnosed as faulty due to problems with connectors, even though the actual component or device is in working condition. Aside from the possibilities of a poor mechanical connection between components and harnesses, poor contact is frequently the consequence of the insulating properties of surface oxides and other contaminants. Often the mere act of disconnecting and re-connecting a component will abrade contact points sufficiently to provide for proper conductivity between mating connectors.

Before an ECU is replaced, all other compo-

nents and wiring relevant to a circuit must be examined by following the steps outlined in a diagnostic fault tree. If the ECU is suspect:

1. Carefully disconnect the ECU from the harness.
2. Inspect the harness connector and ECU for foreign material on the connector pins. Wipe the connector pins with a standard contact cleaner to remove any oxides, contamination, etc.
3. Inspect the ECU harness connector for bent or missing pins, broken wires, missing wires, improper or missing insulation, etc. Repair or replace as necessary.
4. Inspect the ECU for bent or missing pins. Replace as necessary.
5. Carefully connect the ECU to the ECU harness and retest using the DRB II diagnostic tester.
6. If the vehicle does not pass the test, and fails with the SAME fault message as experienced earlier, replace the ECU.

## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

#### MECHANICAL

##### FUEL PRESSURE TEST (Fig. 34)

1. Remove the cap from the pressure test port on the fuel rail.
2. Connect the 0-60 psi fuel gauge from the MS 1942 FUEL GAUGE SET or equivalent, to the pressure fitting on the fuel rail.
3. Start the vehicle, the fuel pressure should be approximately 31 psi with the vacuum hose connected to the pressure regulator. The fuel pressure should be approximately 39 psi with the vacuum hose disconnected from the pressure regulator.

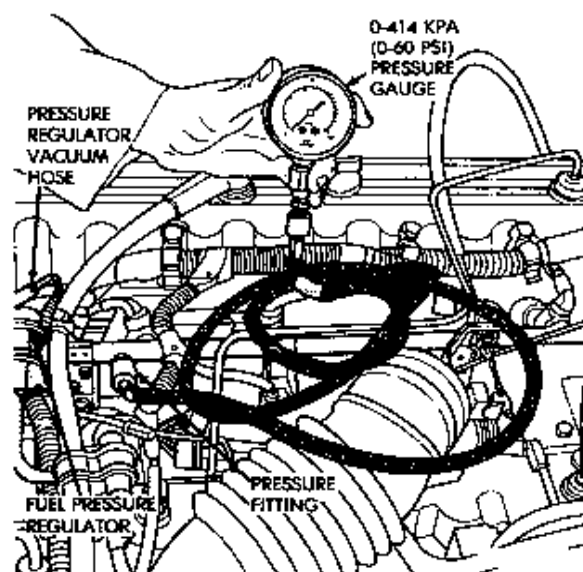


Figure 34 - Fuel Pressure Test

##### FUEL SYSTEM PRESSURE RELEASE PROCEDURE

The 4.0 liter fuel system is under constant pressure of 19 to 39 psi. This pressure must be released before servicing any fuel supply or return system component.

1. Disconnect the battery negative cable.

2. Remove the fuel tank filler neck cap to release fuel tank pressure.
3. Remove the cap from the pressure test port on the fuel rail.

**WARNING: DO NOT ALLOW FUEL TO SPILL ONTO THE ENGINE INTAKE MANIFOLDS. PLACE SHOP TOWELS UNDER THE PRESSURE PORT TO ABSORB FUEL WHEN THE PRESSURE IS RELEASED FROM THE FUEL RAIL.**

4. Place shop towels under the fuel pressure test port.
5. Using a small screwdriver or pin punch, push the test port schrader valve in to relieve the pressure. Absorb spilled fuel with shop towels.
6. Remove shop towels and dispose of properly.
7. Install cap over pressure test port.
8. Install fuel tank filler neck cap.

#### ELECTRICAL

##### DRB II DIAGNOSTIC TESTER

Use the DRB II diagnostic tester along with the Jeep/Eagle adaptor # 0T53129 on all 1987 - 1990 fuel injected models. Refer to the Powertrain Diagnostic Procedure manuals for fault codes and test procedures.

The DRB II diagnostic tester and adaptor will be able to perform System Tests, State Display, and Throttle Position Sensor (TPS) adjustments on the fuel system. The DRB II will also be able to display faults that can be stored in the ECU'S "ON BOARD" diagnostics.

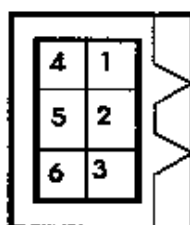
##### IDLE SPEED STEPPER MOTOR TESTING

Refer to the Idle Speed Stepper Motor component testing section of this book.

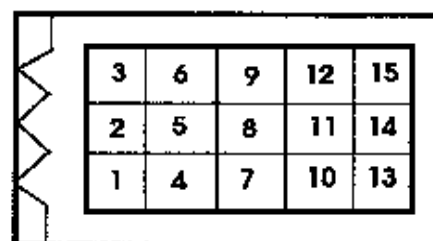
## 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

### SYSTEM DIAGNOSIS

#### DIAGNOSTIC CONNECTOR PIN LOCATION



CONNECTOR D1



CONNECTOR D2

#### 1987 - 88 MODELS

##### CONNECTOR D1

1. TACH SIGNAL
2. NOT USED
3. ECU GROUND
4. NOT USED
5. BATTERY (+)
6. FUEL PUMP (+)

##### CONNECTOR D2

1. ECU OUTPUT (TX)
2. RX DATA (ECU)
3. LATCH RELAY
4. IGNITION
5. LATCH B +
6. A/C CLUTCH
7. IGNITION GROUND
8. SENSOR GROUND
9. OXYGEN SENSOR HEATER
10. NOT USED
11. SHIFT LAMP
12. NOT USED
13. NOT USED
14. NOT USED
15. AUTOMATIC TRANSMISSION DIAGNOSIS

#### 1989 - 90 MODELS

##### CONNECTOR D1

1. TACH SIGNAL
2. NOT USED
3. ECU GROUND
4. ANTI-LOCK BRAKES
5. BATTERY (+)
6. FUEL PUMP (+)

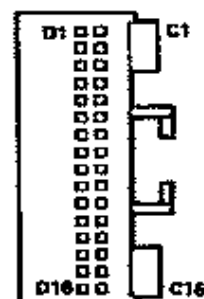
##### CONNECTOR D2

1. ECU OUTPUT (TX)
2. RX DATA (ECU)
3. LATCH RELAY
4. IGNITION
5. ANTI-LOCK BRAKES
6. A/C CLUTCH
7. IGNITION GROUND
8. SENSOR GROUND
9. OXYGEN SENSOR HEATER
10. NOT USED
11. SHIFT LAMP
12. B+ LATCH
13. NOT USED
14. CHECK ANTI-LOCK BRAKES
15. AUTOMATIC TRANSMISSION DIAGNOSIS

# 4.0 L MULTI-POINT FUEL INJECTION SYSTEM

## SYSTEM DIAGNOSIS

### ECU CONNECTOR PIN LOCATION 1987 - 90 MODELS



#### A

1. INJECTOR # 3
2. INJECTOR # 6
3. INJECTOR # 2
4. INJECTOR # 4
5. FUEL PUMP RELAY
6. NOT USED
7. OXYGEN SENSOR RELAY
8. SHIFT LAMP
9. LATCH RELAY
10. EGR/EVAP SOLENOID
11. NOT USED
12. A/C RELAY

#### B

1. INJECTOR # 1
2. INJECTOR # 5
3. AIS A
4. AIS A<sup>1</sup>
5. AIS C
6. AIS C<sup>1</sup>
7. BATTERY (+)
8. IGNITION
9. NOT USED
10. LATCHED B+
11. GROUND
12. GROUND

#### C

1. SPEED SENSOR (+)
2. A/C REQUEST
3. START
4. P/N SWITCH
5. SYNC.
6. MAP SENSOR
7. TPS SENSOR
8. AIR TEMPERATURE SENSOR
9. NOT USED
10. COOLANT TEMPERATURE SENSOR
11. INJECTION SUPPLY
12. TX (SERIAL DATA)
13. NOT USED
14. MAP SENSOR SUPPLY (+)
15. TPS SUPPLY (+)
16. SYNC. (+)

#### D

1. SPEED SENSOR (-)
2. A/C SELECT
3. SENSOR GROUND
4. NOT USED
5. NOT USED
6. NOT USED
7. NOT USED
8. KNOCK SENSOR GROUND
9. OXYGEN SENSOR INPUT
10. INJECTION SUPPLY
11. RX (SERIAL DATA)
12. NOT USED
13. SPARK/DWELL
14. NOT USED
15. NOT USED
16. KNOCK SENSOR



[illegible]



[illegible]

[illegible]

[illegible]

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DEVELOPMENT DEPARTMENT**



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